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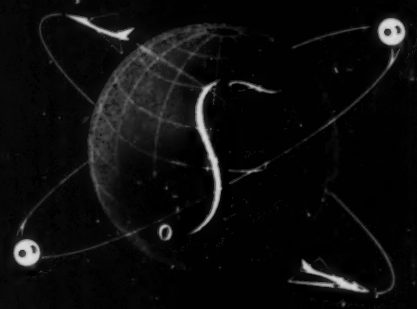
Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT



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ALLIS-CHALMERS ELECTRICAL REVIEW
Allis-Chalmers Mfg. Co.
Milwaukee 1. Wisconsin

APPLICATIONS AND INDUSTRY
American Institute of Electrical Engineers
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JOURNAL OF APPLIED MECHANICS
American Society of Mechanical Engineers
29 West 39th Street
New York 18, New York

JOURNAL OF APPLIED PHYSICS
American Institute of Physics
335 East 45 Street
New York 17, New York

ASTM BULLETIN
American Society for Testing Materials
1916 Race Street, Philadelphia 3, Pa.

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Bell Telephone Laboratories
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COMMUNICATIONS AND ELECTRONICS
American Institute of Electrical Engineers
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CORROSION
National Association of Corrosion Engineers
M & M Building, Houston 2, Texas

DROP FORGINGS TOPICS
Drop Forging Association
605 Hanna Building
Cleveland 15, Ohio

ELECTRICAL ENGINEERING
American Institute of Electrical Engineers
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ELECTRONIC ENGINEERING
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Strand, London, W. C. 2

ENGINEER (Western Electric)
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New York 7, New York

JOURNAL OF ENGINEERING EDUCATION
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Lancaster, Pennsylvania

ENGINEERING LOG
Ford Instrument Company
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Long Island City 1, New York

ENVIRONMENTAL QUARTERLY
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Grand Central Station
New York 17, New York

FRONTIER
Armour Research Foundation
10 West 35 Street
Chicago 16, Illinois

GENERAL ELECTRIC REVIEW
General Electric Co.
One River Road
Schenectady 5, New York

GENERAL MOTORS ENGINEERING JOURNAL
General Motors Technical Center
P. O. Box 177, North End Station
Detroit 2, Michigan

GRAY IRON NEWS
Gray Iron Founders' Society
210 National City, E. 6th Building
Cleveland 14, Ohio

JOURNAL OF THE INSTRUMENT SOCIETY OF AMERICA
Instrument Society of America
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Pittsburgh 22, Pa.

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New York 5, New York

INSTRUMENTATION
Minneapolis-Honeywell Regulator Co.
Wayne and Windrim Avenues
Philadelphia 44, Pa.

IRON & STEEL ENGINEER
Association of Iron and Steel Engineers
1010 Empire Bldg.
Pittsburgh 22, Pa.

JET PROPULSION
500 Fifth Avenue
New York 36, New York

LUBRICATION ENGINEERING
American Society of Lubrication Engineers
84 East Randolph Street
Chicago 1, Illinois

METALWORKING PRODUCTION
McGraw-Hill Publishing Co., Ltd.
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London, E. C. 4, England

THE MAGAZINE OF MAGNESIUM
Brook & Perkins
1950 West Fort Street
Detroit 16, Michigan

THE MAINSPRING
Associated Spring Corporation
Bristol, Connecticut

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American Society of Mechanical Engineers
29 West 39th Street
New York 18, New York

MECHANICAL WORLD & ENGINEERING RECORD
31 King Street, West
Manchester 3, England

METAL PROGRESS
American Society for Metals
7301 Euclid Avenue
Cleveland 3, Ohio

JOURNAL OF METALS
American Institute of Mining, Metallurgical and Petroleum Engineers
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New York 18, New York

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ORDNANCE
American Ordnance Association
708 Mills Building
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PLASTICS
Bowling Green Lane
London, E. C. 1

PLATING
American Electroplaters' Society
445 Broad Street
Newark 2, New Jersey

THE RESEARCH ENGINEER
Engineering Experiment Station
Georgia Institute of Technology
Atlanta, Georgia

SAE JOURNAL
Society of Automotive Engineers
485 Lexington Avenue
New York 17, New York

SPE JOURNAL
Society of Plastics Engineers
65 Prospect Street
Stamford, Connecticut

THE MAGAZINE OF STANDARDS
American Standards Association
70 East 45 Street
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TECHNICAL JOURNAL
American Telephone & Telegraph Company
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TECHNICAL NOTES
National Advisory Committee for Aeronautics
Washington, D. C.

THE TOOL ENGINEER
American Society of Tool Engineers
10700 Puritan Avenue
Detroit 38, Michigan

WELDING JOURNAL
American Welding Society
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WESTINGHOUSE ENGINEERS
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National Metal Exposition Congress
Pressed Metal Institute
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Society of Plastics Engineers
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AIRFLEX The Falk Corporation
AIR-GRIP Dodge Mfg. Corp.
AIRPURE Flanders Filters, Inc.
AIRTROL Reeves Pulley Co. Div. of Reliance Elec. & Eng. Co.
ALCHROME Wilbur B. Driver Co.
ALCUPLATE Metals & Controls (Div. Texas Instruments, Inc.)
ALGCO The Auburn Mfg. Co.
ALIRON Metals & Controls (Div. Texas Instruments, Inc.)
ALL FLEX Allied Metal Hose Co.
ALL-MOTOR The Falk Corporation
ALNIFER Metals & Controls (Div. Texas Instruments, Inc.)
ALODINE Amchem Products, Inc.
ARMASTEEL Central Foundry Div., General Motors Corp.
ARNOX Arnold Engineering Co.

BALCO Wilbur B. Driver Co.
BEAD BELT Voland & Sons
BERALOY Wilbur B. Driver Co.
BOARD MASTER Universal Drafting Machine Corp.
BONDMASTER Rubber & Asbestos Corp.
BOST-BRONZ Boston Gear Works

CAGEROL McGill Mfg. Co., Inc., Bearing Div.
CAMROL McGill Mfg. Co., Inc., Bearing Div.
CARMET Allegheny Ludlum Steel Corp.
CELORON Continental Diamond Fibre Corp.
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CUPRON Wilbur B. Driver Co.
CUSTOMEERING The Ohio Rubber Co.
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DAZIC Winterburn Mfg. Co.
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DEOXIDINE Amchem Products, Inc.
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DIALCO Dialight Corp.
DIAMOND Continental Diamond Fibre Corp.
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DI-CLAD Continental Diamond Fibre Corp.
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DILECTO Continental Diamond Fibre Corp.
DISC-PAC Carlyle Johnson Machine Co.
DOT United-Carr Fastener Corp., Carr Fastener Co. Div.
DUAL-LOCK Simmons Fastener Corporation
DUOCARB Wilbur B. Driver Co.
DURAN CLAD Masland Duraleather Co.
DURA-SEAL Durametallic Corp.
DURIDINE Amchem Products, Inc.
DUROID Rogers Corporation
DYNACO Dynamic Gear Co.
DYNA-LINE Guardian Products Corp.
DYNA-V Dodge Mfg. Corp.

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ELECTRO-SHEAVE Warner Electric Brake & Clutch Co.

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EVANOHM Wilbur B. Driver Co.

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FLAT-TOP Allied Research Products, Inc.
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FLEXIDYNE Dodge Mfg. Corp.
FLEXON Flexonics Corporation
FLEXPIPE Anaconda Metal Hose Div., American Brass Co.
FLO LINE Hanna Engineering Works
FLO SET Hanna Engineering Works
EXPANDURE Flanders Filters, Inc.
FORMWELD Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co.

G-T RING Greene, Tweed & Co.
GASK-O-SEAL Parker Seal Co., Div. Parker-Hannifin Corp.
GEAR-GRIP Guardian Products Corp.
GEARMOTOR Philadelphia Gear Corp.
GEARMOTORS Link-Belt Co.
GIBSILOY Gibson Electric Co.
GRANODINE Amchem Products, Inc.
GRAPHALLOY Graphite Metallizing Corp.
GRIPCO Grip Nut Co.
GRIPMASTER George Walker Co.
GUIDEROL McGill Mfg. Co., Inc., Bearing Div.
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HELE-SHAW American Engineering Co., Hydraulic Pump Div.
HELIARC Linde Co., A Division of Union Carbide Corp.
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HI-FAX Hercules Powder Co.
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HI-SPEED Philadelphia Gear Corp.
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KLOZURE The Garlock Packing Co.
KOYO International Ball & Roller Bearing Corp.
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LA-LED La Salle Steel Co.
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LINK-LOCK Simmons Fastener Corp.
LION Southco Div., South Chester Corp.
LITHOFORM Amchem Products, Inc.
LOCALITIES Fostoria Corporation
LOCK-O-SEAL Parker Seal Co., Div. Parker-Hannifin Corp.
LOGANSQUARE Logansport Machine Co., Inc.
LOK-THRED National Screw & Mfg. Co.
LOYD SCRUGGS Howard Industries, Inc.
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MAC-IRON Mack Iron Works Co.
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MAY-O-MATIC Mayline Co.
MET-O-SEAL Parker Seal Co., Div. Parker-Hannifin Corp.
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MICROPOTS Borg Equipment Div., Amphenol-Borg Electronics Corp.
MICRO-VELVET Hoover Ball & Bearing Co.
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MINI-MITE Set Screw & Mfg. Co.
MONOBALL Southwest Products Co.
MORLIFE Rockford Clutch Div., Borg-Warner Corp.
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PERMA-CODE W. H. Brady Co.
PHENOLITE National Vulcanized Fibre Company
PLACE National Screw & Mfg. Co.
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POWDRAULIC Hanna Engineering Works
POWERGEAR Morse Chain Co.
POWERGRIP United States Rubber Co., Mech. Goods Div.
POWERIZED Royal Electric Corp.
POWERMITE Tuthill Pump Co.
POWERSPINNING Phoenix Products Co.
PRE-LODE Parker-Kalon, Div. General American Transportation Corp.
PRE-PRINT Clearprint Paper Co.
PRO-FAX Hercules Powder Co.
PUSHNUT Palnut Co.
PYRAMID Greene, Tweed & Co.

QUICK-LOCK Simmons Fastener Corp.

Rx MET WaiMet Alloys Co.
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RATIOMOTOR Boston Gear Works
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REDUCTOR Boston Gear Works
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REVERS-O-MATIC Funk Mfg. Co.
REYNOSOL Reynolds Chemical Products Co.
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ROYAL ROLL Faultless Caster Corp.

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UNITITE Hanna Engineering Works

VEL BUNA The Vellumoid Co.
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NEW YORK, N. Y.

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PRODUCT ENGINEERING
330 WEST 42nd STREET
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DESIGN DIGEST ISSUE

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NEW YORK, N. Y.

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PRODUCT ENGINEERING
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THREE EASY STEPS

1. Fill in key number of advertisement, key letter *and* number for catalogs
2. PRINT name, title, address and company name
3. Drop in mailbox . . . we'll do the rest.

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product
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Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

*MULTIPLE PRODUCT ADS	
Key No.	Specific Product
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Please print or type

Name ..... Title .....

Company .....

Street .....

City ..... Zone ..... State .....

*Where advertisements list more than one product, indicate in box on card the key numbers and specific product in which you are interested

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information... promptly, conveniently...

THREE EASY STEPS

1. **Fill in key number of advertisement, key letter *and* number for catalogs**
2. **PRINT name, title, address and company name**
3. **Drop in mailbox . . . we'll do the rest.**

In this 8th Design Digest Issue, we have over 200 advertised products and over 1500 manufacturers' bulletins and catalogs offered.

Rather than confuse you with a maze of over 1700 printed numbers, we have provided blank spaces on these reader service cards. All you need do is write in the key number printed at the bottom of the advertisement in which you are interested. Each catalog listed has a key number and prefix letter before its description. Simply write in the letter and number on one of these cards for any catalog or bulletin offered which interests you.

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*MULTIPLE PRODUCT ADS

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Please print or type

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Street .....

City ..... Zone ..... State .....

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new ARTICLES,

added FEATURES, *increased* VALUE

No specific editorial service offered by PRODUCT ENGINEERING receives as much favorable comment from you as the Design Digest Issues. To keep up with the swiftly moving field of product design, research and development we have continually improved these issues for easier use and reference. No issue includes any material which has appeared in another unless there has been an important contribution in the subject area which demands updating of the previously published article.

Previous issues used articles from PRODUCT ENGINEERING, but with our reprint service and tear-out pages for the Design Roundups and Reference Book Sheets, it is no longer necessary to include these. A simple change but one which permits us to give you more basic material from other sources; in fact less than 1% of this issue contains material previously published in PRODUCT ENGINEERING.

Our original premise—to offer you, the design engineer, a basic reference file oriented to your needs and interests—has never changed. With each succeeding issue we have added to that file until today, it represents a reference library of unprecedented value. To make the Design Digest even more valuable, two new features are included in this issue.

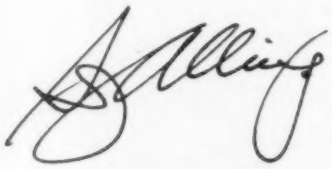
FIRST: At the beginning of each section there is a series of abstracts. These are from articles read by our editors but not used in full or in digest form. It is impossible to include all available worthwhile material in a single volume of this kind, so our editors include those with the widest appeal. Many, without this broad interest are just as significant, but in a more selective way. These have been abstracted.

SECOND: Every year manufacturers produce millions of pages of new catalog and bulletin information (technical and reference) about their products. These are distributed far and wide, but when you want information, often you can't find it. So we have undertaken the task of listing some 1600 bulletins and catalogs, many issued since the previous Design Digest. Here then, is a central source for this important type of reference material. If you need any, fill out a Reader Service Card at the front of the issue and send it in. If you want to write on your company letterhead direct to the manufacturer you can save a handling and time. We trust you will mention PRODUCT ENGINEERING.

Obviously, this caused a change in our Reader Service Card. To list all the information, a full-page card would have been needed, awkward and unwieldy to handle both for you and us. So instead you simply write in the prefix letter and number (B81, C52, etc) of the catalog or bulletin you want; or just the number indicated, for information on any advertisement.

If you do not have access to this issue regularly and would like a copy for your personal library, remember it is a part of our regular subscription. By sending in your subscription order—either on the card or by letter—you can start receiving PRODUCT ENGINEERING with this issue. In addition, we have just over 100 copies of the last Design Digest Issue left. If your new subscription order reaches us by October 19 we will give you one as long as our supply lasts.

In our field of technical magazine publishing, as in your field of engineering design, research and development, *Progress Begets Change*. But our promise to offer you the best in the publishing field will never change.



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DESIGN ABSTRACTS

GUARD YOUR "KNOW-HOW" SECRETS

Failure to safeguard your company's technical know-how may result in loss of valuable rights. Disclosure of technical know-how to the people closely involved in carrying out a business operation cannot be easily avoided. However, despite these disclosures, the law of trade secrets as applied by the courts today affords the businessman a large measure of protection for technical know-how."

The term "technical know-how," as used today, covers the accumulated skill, experience, special techniques, and technological information which enable a company to design and manufacture a product successfully. It does not include the patents of a company.

Although technical know-how is not carried on the company's balance sheet, it is a most important asset. The acquisition of this asset represents a sizable investment. Unlike a company's physical plant or inventory, the company's technical know-how can be inadvertently donated to competitors if it is not adequately safeguarded.

Keep it confidential

To maintain the character of the confidential information does not require that it be kept absolutely secret. In any large manufacturing operation drawings containing proprietary information must necessarily be distributed to various employes and, in some instances, to outsiders. If the disclosure is limited to those personnel who need to know the information, and who are instructed not to divulge the information to others, the rights of the company are not jeopardized.

"Keep It Confidential," Henry J Marciniak, Allis-Chalmers Mfg. Co; Allis-Chalmers Review, First Quarter, 1959, Milwaukee 1, Wis.

*

Subjective Measurements

Stating that "every act of measurement involves a human judgment," differentiations are discussed between what are termed "physical" and "subjective" measurements. Precision of measurement is determined by rating reproducibility capacities of the system used. Whether goal of measuring procedures is engineering or scientific work, established principles for the design of experiments should be applied.

"Subjective Measures in Engineering," John Versace, Chrysler Corp; SAE paper 2.S, 485 Lexington Ave, New York 17.

*

Dimensions of Machine Assemblies

Statistical procedures used in quality control and acceptance sampling methods developed for maintaining standards in individual machine parts are applied to dimensioning of assemblies. Standard deviations, dimensioning of clearance fit, dimensioning of assembly with unknown deviations, overlapping tolerances are discussed.

"Application of Statistics to Dimensioning of Machine Parts," M F Spotts, Northwestern University, ASME paper 58-A-44, 29 W 39th St, New York 18.

*

Consulting Engineers

There is much about the private practice of engineering that is not as it should be, and often those who see these faults best are not the consulting engineers themselves but the manufacturers and suppliers who deal with them.

Faults

A man (or a profession) must recognize his sins before he can stop sinning, and sometimes these sins have to be pointed out by others. With this in mind, 200 prominent manufacturers were asked to tell what faults they observed in consulting engineers—technical faults, professional faults, and business faults.

In nearly every instance the manufacturers pointed out plainly that their condemnations applied only to a minority of engineers in private practice. There is no more indication of malpractice in engineering than there is in medicine or law, but what there is seriously damages the standing of the profession and should be wiped out.

"What's Wrong With Consulting Engineers," Consulting Engineer, June '59, Wayne near Pleasant St, St. Joseph, Mich.

*

Use of Engineering Talent

To make optimum use of engineering personnel, four suggestions are made and discussed: (1) match men and jobs so that every man is challenged and given opportunity to grow; (2) find ways to concentrate engineers' time on engineering work; (3) cooperation between educators and industry to produce best practicable engineering raw material, and conversion into high-quality engineers in shortest possible time; (4) circumvent organizational pitfalls that are likely to result in bureaucratic waste of engineering talent.

"Utilization of Engineering Talent," H B Huntley, American Telephone & Telegraph Co; Electrical Engineering, Jan '59, 33 W 39th St, New York 18.

*

Two on Statistics

"Theory of Extreme Values," by J Mandel, National Bureau of Standards, (ASTM Bulletin, Feb '59) reviews basic concepts and results of this theory, particularly as it pertains to testing and the preparation of specifications.

"Should Statistical Methods Be Used to Prepare Material Specifications?", by Sheppard and Ginsburg, Westinghouse Electric Corp (also from ASTM Bulletin, Feb '59), consists of an analysis of some of the

problems involved in this question. How statistical methods are applied, a discussion of risks, minimum average specification values are among subjects discussed.

ASTM Bulletin, 1916 Race St, Philadelphia 3.

*

Critical Tables

Role of critical tables of scientific and engineering data in the present-day American technological society is discussed and their history summarized. Objectives and functions of the National Research Council's new Office of Critical Tables are described.

"How Critical Are Critical Tables?", Allen V Astin, Director, National Bureau of Standards. Presented at Symposium of Thermal Properties of Gases, Liquids and Solids, Purdue University, Lafayette, Ind.

*

Organized Plant Lubrication

Reasons for a planned, plant-wide lubricating system and schedule are reviewed. Necessary management steps and required personnel are discussed. Survey of equipment needs, required lubricants, methods and apparatus for application, both manual and automatics, are described.

"Organized Plant Lubrication," Lubrication, July '58; Texas Co, 135 E 42nd St, New York 17.

*

Storing and Availability Of Engineering Data

"A Blueprint for Storage and Retrieving of Coded Mechanical Engineering Data," E. G. Gilbo, Custom Mechanical Parts Mfg., ASME paper 58-SA-6, describes use of electronic data-processing machines and a code system for documentary and product-file information needed for research and development, design, standardization.

"Orderly and Economic Handling of Engineering Data," T. W. Schwartz, E. I. du Pont de Nemours & Co., ASME paper 58-SA-49, discusses relative merits of various documentation systems in terms of cost, simplicity, adaptability, compactness. An indexing system based on associative check lists of words related to individual subject headings and called "concept coordination" is described and evaluated.

ASME, 33 W 39th St, New York 18.

*

Correlation Analysis

Curve plotting may be applied to engineering problems when all factors except the two being studies can be held constant, yet there are situations where this is impossible. Correlation analysis—not new, but also not widely used—can be used even where there are several variables. This is done by calculating equations of the most probable line, called the line of regression, and only simple arithmetic is employed—although algebra and calculus are used to establish validity. Several practical applications from actual engineering practice are given.

"Applying Correlation Analysis to Engineering Problems," George Shombert, Allis-Chalmers Electrical Review, 3rd Quarter '58, Milwaukee. 1.

*

Three on Designing by Computer

Optimum Machine Design by Digital Computer," by G L Godwin, Westinghouse Electric Corp (AIEE paper 59-57), states that errors in machine design calculations carried out by computer were just about nonexistent. Designing cost is about the same. Savings must come from better use of materials, greater sales, better product performance. Some predictions of probable future applications to design are made.

"Motor Speed-torque Curves by Digital Computer," by J M Shulman, Westinghouse Electric Corp (AIEE paper CP 59-133), points out the costliness of extensive speed-torque testing, then discusses limitations encountered when verification of design calculations is attempted on analog computers. Gives advantages, procedure for application of digital equipment.

"Synthesis of Induction Motor Designs on a Digital Computer," C G Veinott, Reliance Electric & Engineering Co (AIEE paper CP 59-131), describes process involved in engineering motors of this type; explains how computer can best be applied.

AIEE, 33 W 39th St, New York 18.

*

Designing the Experiment

A procedure for determining in advance the degree of decision ability inherent in a proposed experiment and ascertaining capacity to measure effects requiring evaluation is described. Sample risk curve, test pattern selection chart, and test sequence are included.

"Designing the Experiment," W J Hill, Ford Instrument Co, Engineering Log, 31-10 Thomson Ave, Long Island City 1, NY

*

When Is a Tolerance Just Right?

Describes method for establishing specifications evolved from statistical control techniques consisting of 3-step method, involving reduction of number of components contributing to excessive variations, equalizing points of manufacturing variances, evaluations and change of tolerances.

"When Is a Tolerance Just Right," Dorian Shainin, Rath & Strong Inc, SAE Journal, Feb '59, 485 Lexington Ave, New York 17.

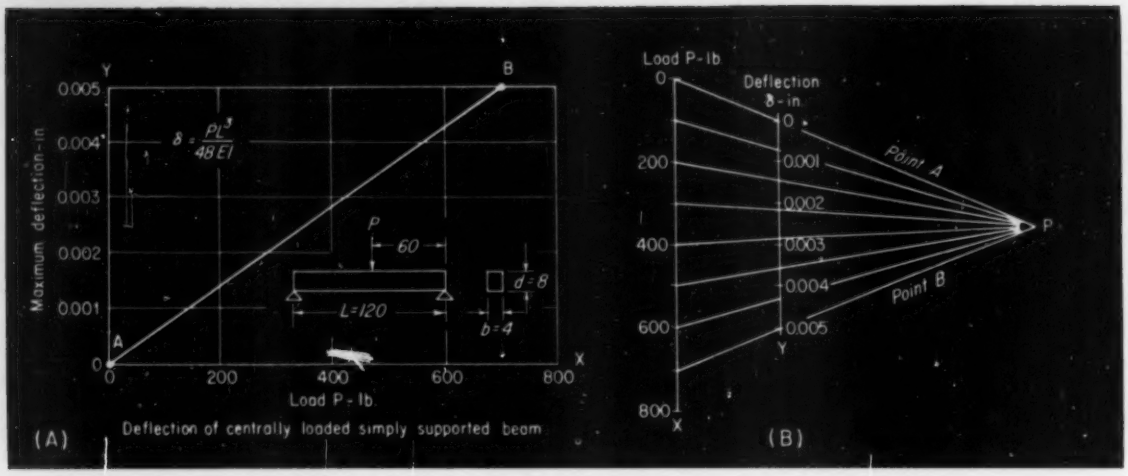

Fig. 1—Alignment nomogram of a single line is simply constructed. (A) Concurrency nomogram. (B) Alignment nomogram.

Construction of Alignment Nomograms

Simplified methods of converting simple curves as well as complex families of curves into alignment nomograms are given. A method of accurately interpolating and extrapolating experimental data is presented. The condition for exact conversion to alignment nomograms is pointed out and an example given.

From: Allis-Chalmers Electrical Review

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Assistant to Director of Mechanical Engineering

R. W. OPPERTHAUSER
C-Stellarator Associates
Allis-Chalmers Manufacturing Company

Empirical data are usually presented in the form of a Cartesian chart, also called a concurrency nomogram. When three or more variables are involved, it is necessary to express the resulting relationships by a family of curves. To give good coverage to the relationships, the family must have a large number of curves with the result that experimentation time to establish these curves through sufficient data points becomes excessive.

By using the technique of alignment nomography, it is possible to reduce experimentation time while increasing the family of curves to any desired number of members. Also, the ease and accuracy of reading the value of a third quantity from a knowledge of two quantities that affect the third are increased substantially.

Alignment nomograms are easier and quicker to use, than most other methods, especially for making repeated calculations. They can be used to extend, through accurate interpolation and extrapolation, the range of experimental data gathered from test results.

CONSTRUCTION FROM EMPIRICAL DATA

Simple nomography. The Cartesian coordinate scales X and Y, corresponding to the scales in Fig. 1(A), are set up parallel to each other and an arbitrary but convenient distance apart, as shown in Fig. 1(B). Any two points A and B which lie on the line in the concurrency nomogram are then chosen, and the coordinates of each point are located in the alignment nomogram. Straight lines drawn through the coordinate points in the two sets of alignment coordinates intersect at point P. Any point in the concurrency nomogram which lies on the given line A-B is represented in the alignment nomogram by a line passing through fixed point P. If the direction of graduation of one of the scales is reversed then point P would fall between the two alignment scales.

Frequently a family of curves, Fig. 2(A), is used to express the relationship between three variables. An alignment nomogram can be constructed for the entire family of curves by choosing points on each curve, and repeating

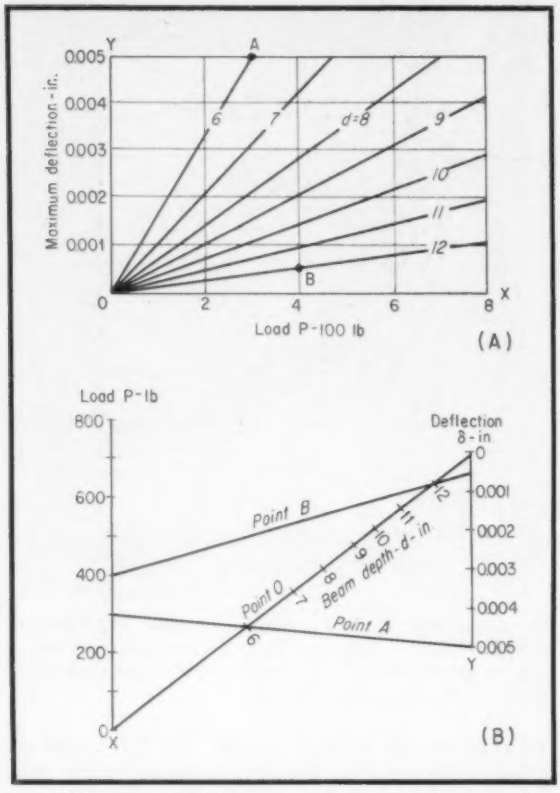


Fig. 2—Construction of alignment nomogram for family of lines makes possible direct interpretation of a third variable. (A) Deflection of centrally loaded simply supported beams of various depth with b = 4 in., L = 120 in. (B) Alignment nomogram of the simply supported beams.

the process for all curves in the family. A different fixed point will exist for each curve. Joining these points gives a third scale, Fig. 2(B), which represents beam depth. Hence, the maximum deflection in the beam of Fig. 1 is obtained for various beam depths.

Rectification of curves. Alignment nomograms can be constructed from nonlinear functions if suitable scales are used. Fig. 3 shows how a curve may be rectified.

A straight line is drawn through the ends of the curve. Points on the X scale are projected vertically to the curve; horizontally to the straight line; then vertically to the X' scale. This is the functional or transformed scale and is used in place of the X scale to construct the alignment nomogram of the curve, using the same method as used for the straight line, Fig. 1. In this manner, the area moment of inertia of rectangular beams with various depth can be obtained.

Two curves in a concurrency nomogram may be rectified simultaneously by using two transformed scales, Fig. 4. A steplike series of lines, a, b, c . . ., is drawn between two curves, which are sufficiently close to permit a minimum of five steps, Fig. 4(a). Two parallel lines are drawn at a convenient angle, Fig. 4(b), and a corresponding

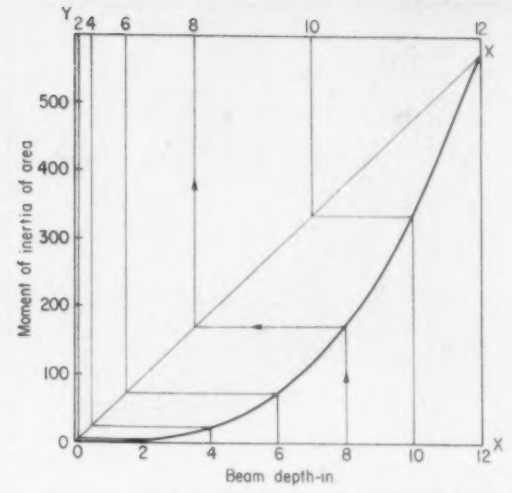


Fig. 3—Transformed scale rectifies a curve into a straight line. Transformed scale is a nomogram.

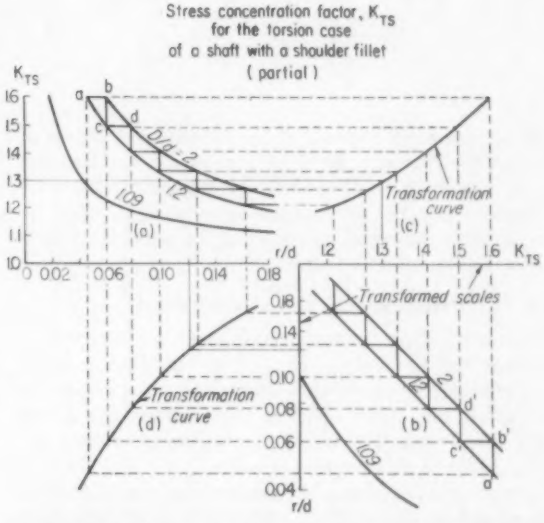


Fig. 4—Family of curves can be rectified by transformation curves. Alignment nomogram is constructed from transformed scales. Angle at which parallel lines are drawn govern the relative lengths of the two transformed scales. Distance between lines governs absolute lengths of these transformed scales.

series of steps, a', b', c'. . . Transformation curves, Figs. 4(c) and (d), are constructed by connecting the respective intersections of the vertical and horizontal steps in Fig. 4(a) and (b). Transformed scales are calibrated by projecting the original scales to the transformation curves and then to the new axes which are perpendicular to the original axes. Using the transformed scales, a nomogram such as shown in Fig. 6(B), can be constructed by the method of Figs. 1 and 2 to find the variables.

Rectification by two transformation curves applied to

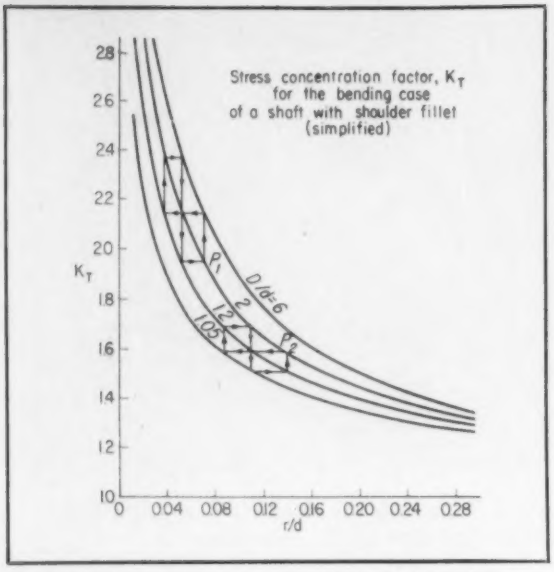


Fig. 5—Method of checking a curve family for bilineality.

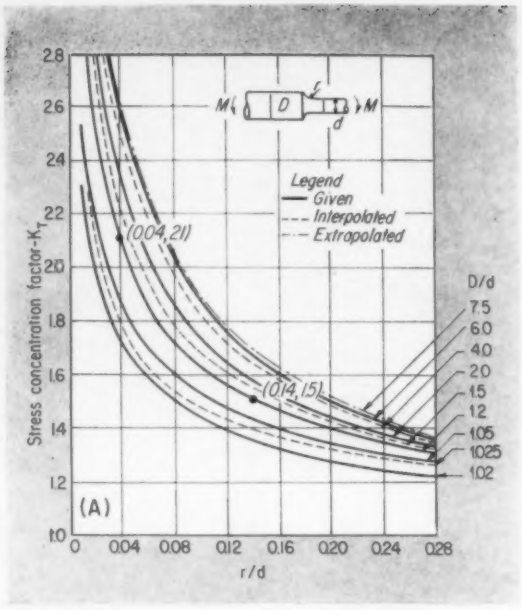


Fig. 6—Interpolation and extrapolation of results. (A) Stress concentration factors in bending. (B) Alignment nomogram extends range of useful data. (C) Graphical method indicating how new points are located on the D/d scale.

only two curves of a family, need not rectify all curves in the family. The curve for $D/d = 1.09$ did not turn out to be a straight line. Only curve families which have bilineality can be transformed into straight lines by rectification. Bilineality exists when the network of lines drawn, Fig. 5, closes on itself.

INTERPOLATION AND EXTRAPOLATION

Curves for stress concentration factors in shafts with a shoulder fillet in bending are given in Fig. 6 (A). Solid lines indicate the curves used to construct the alignment nomogram, Fig. 6(B). Broken lines indicate the curves interpolated with the use of the alignment nomogram; dot-dash line is an extrapolated curve.

Interpolation is done by constructing the alignment nomogram by the methods previously used, and then calibrating the third, D/d, scale into finer divisions by the method shown in Fig. 6(C). Method consists of laying out a linear scale perpendicular to the projected D/d scale as shown in Fig. 6(C), and forming a transformation curve from the intersection of corresponding points projected from the two scales.

In Fig. 6(C), the projected scale is laid out at an angle of 60° with the original D/d scale to expand the D/d scale via the inclined projection technique and to make the transformation curve more accurate. A second expanded linear scale is used to calibrate the lower end of the D/d scale, where a small change in value corresponds to a large change of length on the D/d scale. The desired D/d value point is laid out on the linear scale and through the transformation curve located on the projected scale and then on the original D/d scale. This point is subsequently translated onto the Fig. 6(B) D/d scale. The values on the left of the D/d scale, Fig. 6(B), were obtained by interpolation and through the use of the transformation curves of Fig. 6(C). The curves for the interpolated points are the broken lines of Fig. 6(A), found by using the alignment nomogram and the corresponding calibrated new points established on the Fig. 6(B) D/d scale.

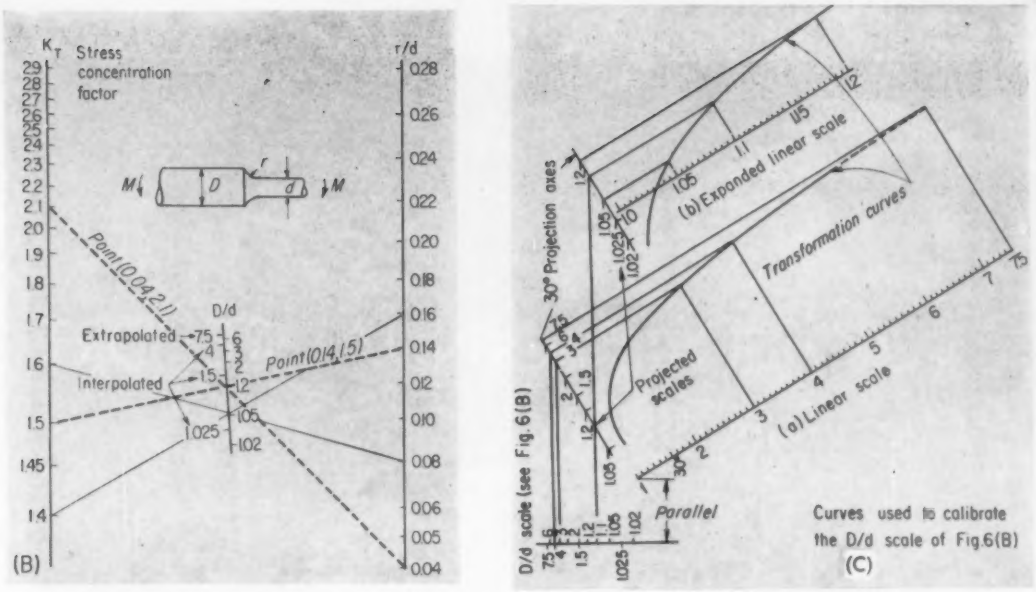
Extrapolation is accomplished by extending to the right the transformation curve of Fig. 6(C), assuming the trend established in this curve would continue in the extrapolated range beyond $D/d = 6$. The same construction procedure is used to locate $D/d = 7.5$ on the scale in Fig. 6(B). Using this point, the extrapolated dot-dash curve of Fig. 6(A) can be drawn.

Accuracy of the extrapolated curve depends on the accuracy of extending the transformation curve in Fig. 6(C); hence, accuracy in extrapolation is limited to a relatively small range.

SIMPLIFICATION OF DATA READING

An example of how alignment nomograms can be used to simplify the reading of data from families of curves are shown in Fig. 7. In Cartesian form, Fig. 7(A), six lines must be drawn to obtain the frequency; the alignment nomogram, Fig. 7(B), needs only three lines. Nomogram is obtained as follows:

L^3/D scale is transformed so that reference curve 1 of Fig. 7(A) becomes a straight line. The transformed but inverted L^3/D scale and the linear frequency scale are laid out parallel and a convenient distance apart, Fig. 7(B). Reference point A, representing reference curve 1, is located on the alignment nomogram. A second, but inverted and linear, L^3/D scale with graduations the same



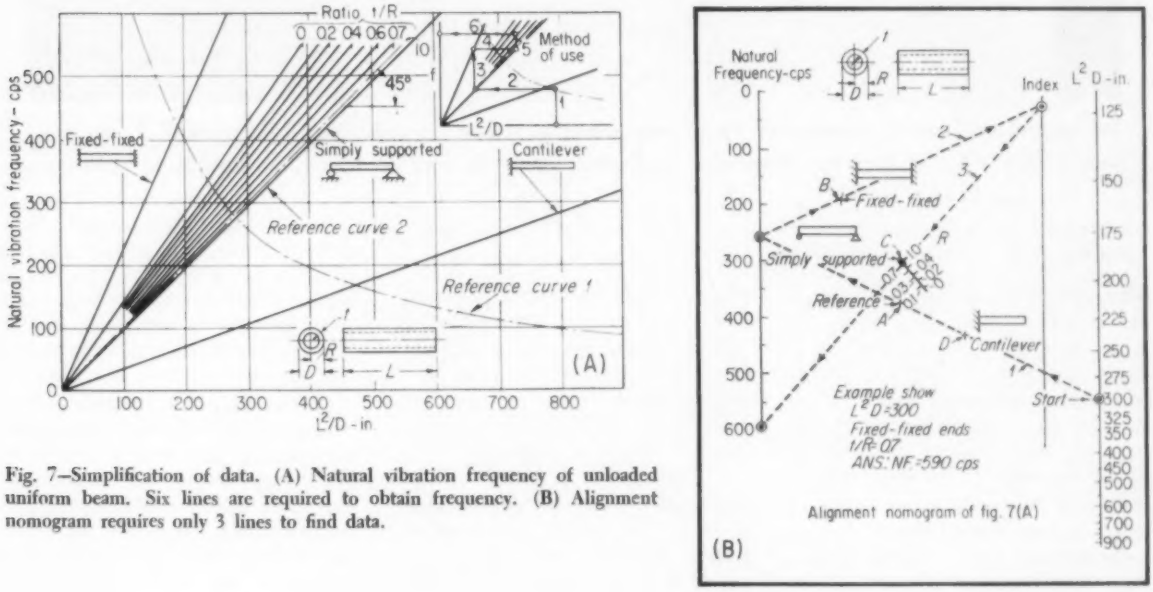


Fig. 7—Simplification of data. (A) Natural vibration frequency of unloaded uniform beam. Six lines are required to obtain frequency. (B) Alignment nomogram requires only 3 lines to find data.

as for the Cartesian L^2/D scale is laid out parallel to the frequency scale at a convenient distance.

The frequency scale in Fig. 7(B), though it represents the ordinates of reference curve 1, is taken to be the abscissa of the type-of-beam-support curves given in Fig. 7(A), and the linear L^2/D scale of Fig. 7(B) is taken as the ordinate of these type-of-beam support curves. These curves are transformed to point *B*, *C*, and *D* in the alignment nomogram. The linear L^2/D scale and the frequency scale are taken as the abscissa and ordinate, respectively, of the curves for various t/R ratios.

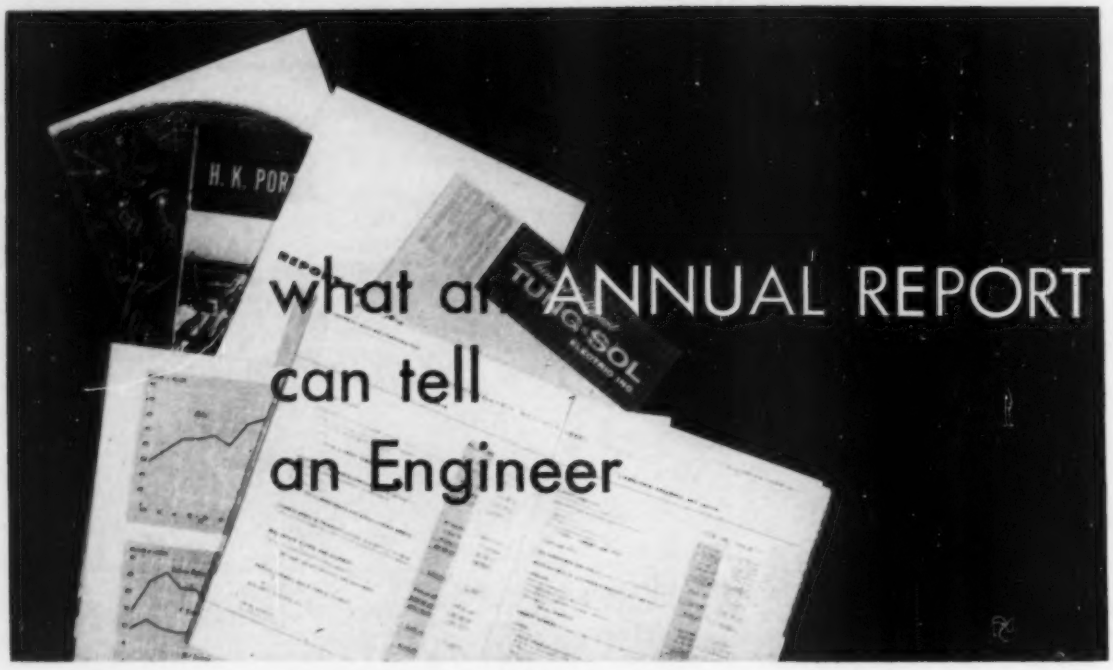
The t/R ratios are then transformed to points which, when joined, give the slant line in the nomogram. Since no numerical values are read from the linear L^2/D scale, the graduations are omitted and it is a reference line.

Hence, the natural vibration frequency of unloaded steel or aluminum beams with a tubular cross section and three different end-support conditions, can be determined conveniently, quickly, and accurately.

REFERENCE:

Construction of Alignment Nomograms by D. B. Kececioglu, Assistant to Director of Mechanical Engineering and R. W. Opperthauser, C-Stellarator Associates, Allis-Chalmers Mfg. Co., Milwaukee, Wisc. Published in the Allis-Chalmers Electrical Review, Second Quarter, 1958, p 11-17.

From: Mechanical Engineering



The corporate report, management's annual statement, can reveal much information it an engineer knows what to look for. Here are some hints on what can be found, and what to check.

WESTON SMITH, Managing Director, Weston Smith Associates

Annual reports are valuable to engineers. These reports have graduated from the simple balance sheet to a broad look at a company's activities, and are readable and useful. They carry much worthwhile information for the sales engineer, purchasing agent, engineering manager, and to many others.

WHAT CAN BE FOUND

By knowing how and what to look for, capital expenditures might be forecast, price breaks in materials may be explained, new products revealed, and competition found.

Sales engineers. Annual reports may well provide a forecast of capital expenditures for the coming year, as compared with past years. This will give a hint as to whether more or less equipment can be sold to the company and, possibly, in what areas and the type of equipment.

Purchasing agents. Corporate reports of suppliers reveal their prosperity and financial worth and the size of their inventories. Perhaps, the reports will indicate future price cuts or increases. In addition, they may disclose new products, almost ready for mass production, or improvements on older products already in production.

Engineering managers. Obtain copies of the annual reports of companies making substitute products. For example, if in the steel industry, the reports of leading aluminum and copper fabricators and some plastic manufacturers would prove helpful. A new or improved raw material or product may prove to be competition and often, the annual report will give additional information not included in the sales brochure of the company.

Engineers. Many engineers send for corporate reports for the prime purpose of finding out if the company would be good to work for, at a time when they are considering a change of job. Annual reports have become highly effective in recruiting engineers, and this is why many reports devote a section to employees.

THE WELL-BALANCED REPORT

The comparative balance sheet provides the figures for only two days: the closing day of two fiscal years. The Asset side of the balance sheet lists everything owned by the company, plus those things owed to the company. The Liability side lists everything the company owes, plus reserves, minority interests, capital, and surplus. The assets of a solvent company are always greater than its liabilities, and the difference is called the Net Worth.

Important is the so-called "Current Position" or the ratio of current assets to current liabilities. Current assets include cash, government bonds, marketable securities, notes and accounts receivable, and inventories (raw materials and supplies, plus work in process or finished merchandise). Current liabilities include bank loans and com-

mercial paper, accounts payable, debentures and other debts due within the coming year, tax accruals, and dividends declared but not paid. Deducting the current liabilities from the current assets gives the net working capital. Generally speaking the net working capital should equal total current liabilities, and if there is an excess of current assets, so much the better.

The working capital ratio is figured by dividing the current liabilities into the current assets, and if the ratio is better than 2 to 1, the current financial condition is satisfactory. However, a high ratio of over 6 to 1 might imply that the company has too much unemployed cash, too many unpaid bills outstanding, or an unusually large inventory of unsold merchandise.

A SOUND COMPANY

When judging the actual financial health of a corporation, it is well to check the "Net Quick Asset" position. By subtracting current liabilities from cash and equivalent and accounts receivable, the Net Quick Assets are determined. When current assets, less inventories, equal or exceed total current liabilities, a corporation is said to be in a sound financial position.

The average industrial company is in the best position when neither bonds nor preferred stock are outstanding ahead of the common stock. If there is bonded indebtedness, not more than 25 per cent of the total capitalization should be in bonds or funded debt. If both bonds and preferred stock are outstanding, the combination of funded debt and preferred stock should not exceed 50 per cent of the total capitalization.

Companies which value their good will, trade-marks, and patents at the nominal value of $1, or at zero, are in a better position than those that carry this intangible asset at millions of dollars. Depreciation of plant and equipment also should be noted, especially if there is a footnote explaining the depreciation policy of the corporation. It is always good policy to read all footnotes, even though they may be set in very small type, because here the independent auditors list the qualifications, exceptions, contingent liabilities, and any pending litigation. If the company has funded debt or loans outstanding which require that the management maintain a certain ratio of current assets to current liabilities or forbid any increase in dividend rate until certain requirements are met, these restrictions will be found in the footnotes.

THE INCOME ACCOUNT

The income account for the latest year provides a variety of information, but is more helpful if the preceding year's income account is also available for a direct comparison. It is only within the past dozen years that the majority of publicly owned companies have been providing sales figures. Today, almost every listed corporation starts its income account with "Net Sales," which represents actual sales after allowances, discounts, refunds, and credits for faulty or returned merchandise. A service company, such as a railroad or electric company, will start its income account with "Gross Income," which represents payments for transportation or utility service.

The first deduction from Net Sales is "Cost of Sales," which includes the prices paid for raw materials, manufacturing wages, depreciation, maintenance, local taxes, fuel, and rent. Next is "Selling and Administrative Expenses," which include nonmanufacturing payments for executive and clerical salaries, salesmen's drawing accounts and commissions, advertising, promotion and public relations, plus other general expenses. This leaves the "Net Operating Income," to which is then added "Other Income," and this includes interest and dividends on securities owned, income from sale of assets, and other profits not considered as operating income. The amount after adding Other Income is available for interest on bonds or other loans, and if such a deduction is made, the balance left is the "Net Income Before Federal Taxes." When the Federal taxes, or the provision for Federal taxes is deducted, the remainder is the "Net Income After Federal Taxes," and if there are no special or nonrecurring deductions, this is the amount for dividends.

WHAT TO CHECK

First, determine the Margin of Profit, which is obtained by dividing the Net Sales into the Net Operating Income, sometimes called the "Net Profit From Operations." The "Profit Margin" for one year does not mean much unless it is compared with something. If the Profit Margins for a series of years are available, it then can be determined as to whether the trend is up or down. Or a comparison can be made with the Profit Margins of other corporations in the same or similar industries to determine an average level for the profits on sales.

Because of the big bite taken by Federal taxes, it has become popular today to determine the post-tax margin of profit, which is determined by dividing the Net Sales into the Net Income After Federal Taxes. Here again, it is necessary to have comparative post-tax profit margins for previous years or figures for competing companies in the same industry, to draw any intelligent conclusions. This is why one of the primary requisites of a modern annual report is a ten-year table of operating and financial statistics, to make quick comparisons with previous years and determine trends. But far too many corporations fail to provide any of the important ratios, such as profit margins (before or after taxes), operating ratio (percentage of all expenses to net sales or gross income), inventory turnover, working capital ratio (ratio of current assets to current liabilities).

Today there are plenty of per-share statistics in annual reports, ranging from earnings and dividends per share on the common stock, to Federal taxes and working capital per share. But very few reports provide the percentages paid out in dividends and the amount retained in the business at the end of each year. Over a period of years, the seasoned industrial company should pay out at least 50 per cent of its earnings in dividends. Growth companies often pay dividends of less than 50 per cent, because they are ploughing back a larger share of earnings to pay for expansion, new equipment, and research.

But in the back part of the well-balanced annual report, more ratios are needed and there is no apparent reason why these ratios and percentages cannot be supplied.

REFERENCE:

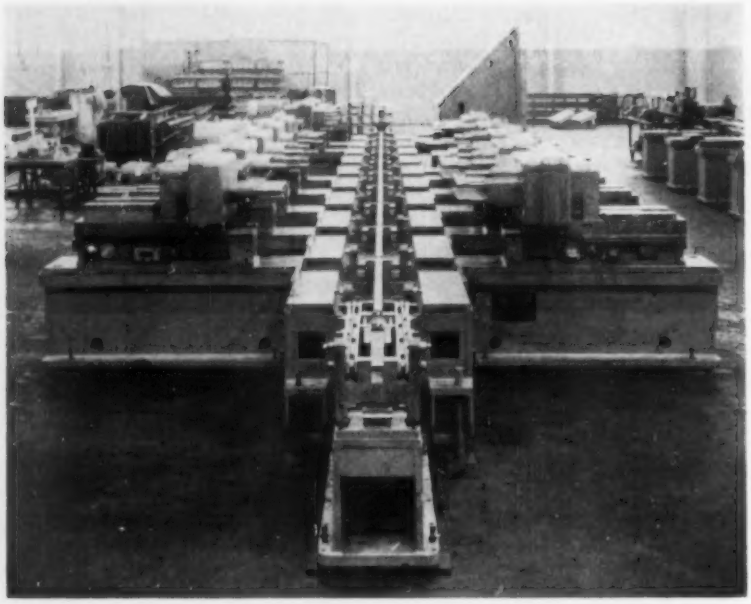
How to Understand an Annual Report by Weston Smith, Managing Director, Weston Smith Associates, New York, NY. Published in Mechanical Engineering, March 1958, p 79-81.

From: SAE Paper

DESIGN FACTORS affecting

KURT O. TECH
Vice President Engineering
The Cross Company

. . . frequently overlooked are: flexibility, accessibility, tool changing, electrical arrangement, work height and identification of machine components.



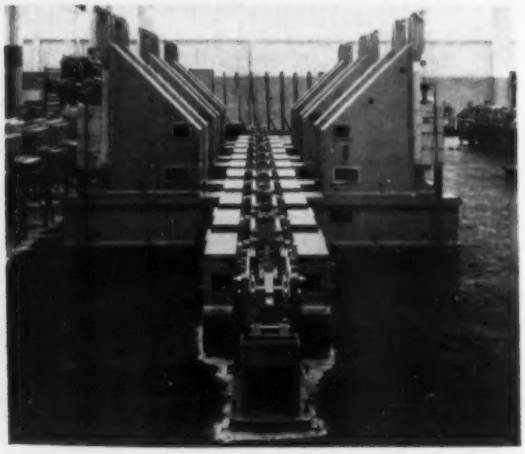


Fig. 1—Flexibility is shown by comparing similar components of two partially completed transfer machines. All components are identical with the exceptions of columns and heads.

1. *Flexibility* is facilitated by maximum standardization in design, dimensions and tolerance. There are three areas of standardization which lead to flexibility: industry, builder and custom.

Industry standardization have been developed by the machine tool and allied industries over a period of years. Included are screws, motors, tool holders, machine tapers and chucks and many other similar items.

Builder standardization are developments of individual companies and give greater interchangeability between components of machines. For example, way-type feed units, wing bases, columns, center base sections, transfer mechanisms and others. This is the building block concept and provides: (1) indentical hole patterns for mounting all units to the machine base; (2) keyed location of units to the machine; and (3) utilization of idle machine station without additional machining.

Custom standardization revolves about fixturing and other components which are directly related to the part being machined. Standardization of part locating pins in all fixtures throughout a transfer line is most commonly known standard.

2. *Accessibility* is one of the most important provisions in machine design to effect shortest possible down time. Machine layout must incorporate space between machine units sufficient for access to the center position of the machine for tool change and fixture maintenance.

Additional floor space is not always needed for accessibility. Careful design and planning of location and

MACHINE EFFICIENCY. . .

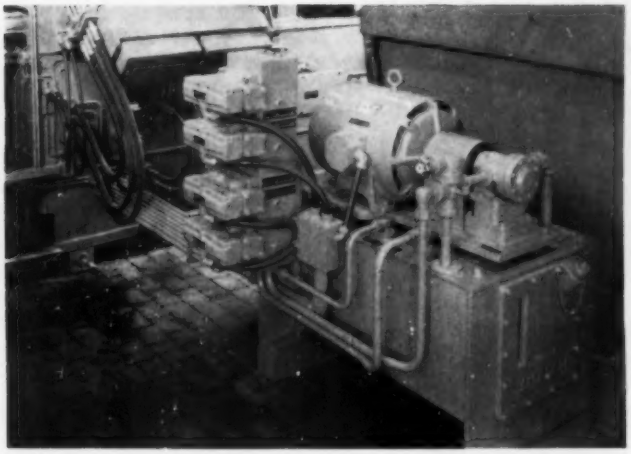


Fig. 2—Accessibility of switches and hydraulic and electrical components. All are out of normally contaminated and dirty areas. Little additional floor space is required for this type of mounting.

arrangement of components is often sufficient. Limit switches, for example, can be mounted away from contamination. Hydraulic control valves can be arranged away from the machine manifold and hydraulic tanks out of danger and easily accessible.

3. *Tool changing* is the greatest cause for machine down time. To expedite changing, pre-set tooling should be planned for wherever possible, and inspection and tool setting should be done off the machine. Replacement tooling should be stored close to the machine.

An integrated system that incorporates a series of signal lights to inform all maintenance personnel—tool setters, operators, repairmen—of tool change periods will permit simultaneous maintenance and reduce down time. In long transfer machine lines, a telephone or code system may have to be incorporated.

4. *Electrical arrangement* can help reduce down time if carefully planned and logically designed. The machine console gives the first indication to the cause of a machine breakdown

Fig. 3—Tool change systems are not inherited with transfer machines; they are planned. Tool setting gages and ready tooling are located close to the machine on which to be used, thus simplifying tool replacement.

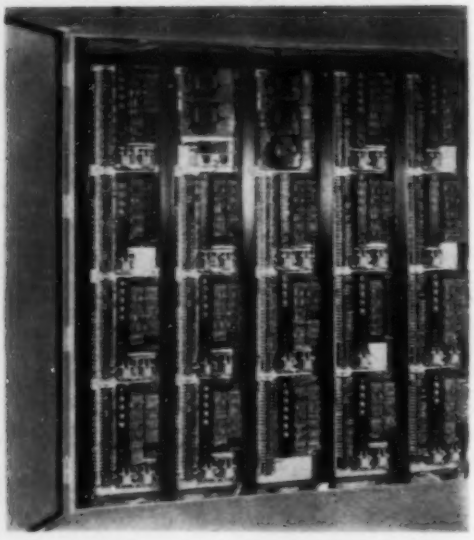


Fig. 4—Electrical arrangement is built up from simple elements and identically located in panels. Building block concept permits faster maintenance and easier training.

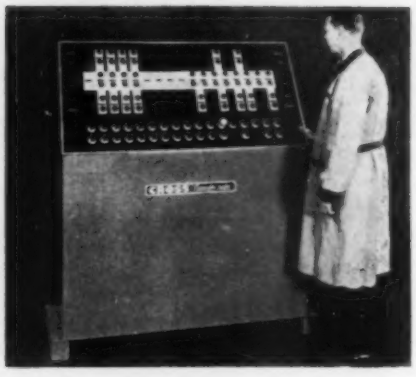
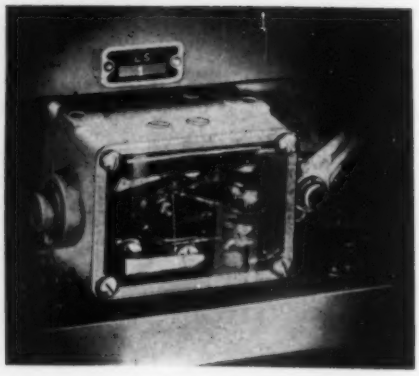


Fig. 5—Identification on machine shows location of valve, as well as solenoid numbers for operation. This allows rapid checking of units when trouble occurs.



and should pinpoint the location of trouble. Console design simulates a plan view of the machine with the required signal lights arranged on this outline in the same relative positions as the devices they represent.

Building block arrangement in control panels provides flexibility for rearrangement of machines and results in multiples of one or more simple circuits, rather than one large complex circuit. Circuits that are broken down into their simplest elements and arranged identically in each control panel will make maintenance easier and considerably reduce down time.

5. *Work height* and structural rigidity must not be compromised for such considerations as operator loading heights or existing conveyor heights. Many times such restrictions seriously affect machine rigidity and proper machine proportions with the base elements.

Space must be provided through the machine for chip conveyors, automatic lubrication systems, coolant systems, hydraulic systems and air lines without sacrificing needed rigidity.

6. *Identification* of all components should be on the machine. Valves, limit switches and cylinders must be tagged for function, for identification in the hydraulic and electrical circuit, and for purchase identification. Relays, timers, starters, wires, and hydraulic lines must be identified so that they can be used to trace circuits.

The location of unit circuits must be tagged outside of control cabinets so that it is unnecessary to open doors to find where specific equipment to be checked is located.

Lubrication instructions must be clearly specified on the machine, and where possible such information should coordinate the eventual users' requirements, as well as the machine tool builders' specifications.

REFERENCE:

Design Factors Affecting Machine Efficiency by Kurt O. Tech, Vice President Engineering, The Cross Company, Detroit, Michigan. Presented at the 1959 SAE Annual Meeting, Detroit, Michigan. Paper No. 41S.

From: Frontier

Profitable Research Planning

R. W. RACE, Research Analyst, Engineering Economic Research Division, Armour Research Foundation

Research is recognized by most businesses as necessary and profit-producing. However, research dollars spent today have their yield in a future year. This leads to a crucial point and one which makes profitable research planning so difficult—the need to make research decisions and plans now to meet anticipated market and product needs several years hence.

DECISION MAKING

Planning for research involves a fundamental notion—how should the decision be made. Decision-making presupposes four mental processes: (1) designating alternative courses of action; (2) estimating the outcome for each course; (3) estimating the probability of attaining the outcome; (4) mentally assigning values to each estimated outcome.

To point up the need for developing bases for decision-making and show how this concept fits into the profitable planning of research, a company—Imaginary Ammonia Company—is assumed.

Executive committee of the company decided to allocate a fixed percentage of sales volume for research. Problem: to determine what research in what area will be of most value or give a minimum return on investment consistent with company goals. Also, the company is interested in ideas or suggestions for research programs. Many companies do not have this problem but must decide which of the many ideas to exploit.

To trigger ideas as to research areas, future markets, product needs, facilities and operations, and the general nature of the ammonia business must be forecast for the company. From this analysis, a list of future needs for research and development are evolved. For example, forecast may show that the smell of ammonia will be intolerable suggesting a deodorizing program. Or that storage is not a future problem, thus no program to design storage facilities is needed.

Planning for Profitable Research

	Deodorizing	Handling	Basic Research	Automation	Secret Process
Cost of Research	$100,000	$50,000	$25,000	$30,000	$100,000
Time of Research	24 months	12 months	6 months	12 months	18 months
Probability of Technical Success	0.2	0.8	0.4	0.9	0.5
Effect on sales	+$5 million	neglig.	+$11 million	neglig.	+$2 million
Investment to exploit	$50,000	$250,000	neglig.	$175,000	$10,000
Addition to profits	$500,000	$400,000	$100,000	$200,000	$200,000
Time span of profits	10 years	2 years	8 years	5 years	3½ years
Return on investment over time	$350,000 over 12 years	$100,000 over 3 years	$75,000 over 8.5 years	$5,000 over 6 years	$90,000 over 5 years

These examples are simplified. More often research programs are based on far more complex and difficult estimates of competitors' strategy, trend of research in the product field, unmet market needs, specific production bottlenecks, and others. An analysis of profit or breakeven points for various product lines also may suggest the need for either internal cost-reduction programs or external market stimulation or analysis work.

PROPER EVALUATION

In sifting the analysis, the executive committee of Imaginary Ammonia Company has agreed on five alternative areas of research and now desire additional information before proceeding. These are: deodorizing ammonia, improved handling techniques, basic research of ammonia reactions, more fully automatic production equipment, and application of ammonia in a secret process.

The next step involves defining the estimated outcomes of each of the five possible opportunities and estimating the probability of attaining these outcomes. Outcomes involve both cost to the company and potential benefits. Cost is a definite factor; benefits are probable.

To evaluate the alternative research programs the following criteria are needed: cost of research; time of research; probability of technical success; effect of volume; probability of commercial success; investment required; time span of profit return; and rate of return.

These items, all of which involve estimates, may form only a part—the objective and factual side—of the criteria of evaluation. Other considerations, many of which may be intangible, will form a part of the final decision. A study team—either company staffed or outside staffed—can provide only the factual basis for the decision; others make the decision.

END RESULT

Facts, figures and estimates must now be added to the proposed chart of criteria. Estimates of the time needed and cost of research and probability of success, must be made and balanced against a market survey to estimate potential and probability of commercial success, and industry studies for an estimate of potential profit and return on investment. After these facts and analyses have been collected in an intensive a fashion as desired, the concept becomes more meaningful as indicated by the chart.

Imaginary Ammonia Company must still choose which research program or programs it wants, but now the bases for decision are present.

REFERENCE:

Profitable Research Planning by R. W. Race. Published in *ARF Frontier*, Fall, 1958, p 14.

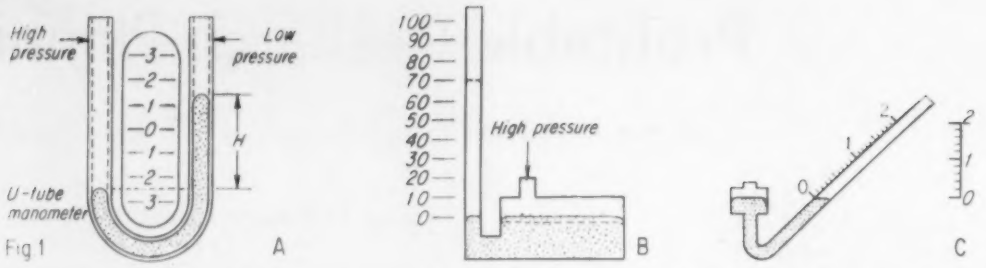


Fig. 1—Manometer types. (A) U configuration is basic. When one leg is connected to the pressure source and the other leg open, the difference in fluid heights accurately indicates pressure or changes in pressure. (B) Well type has a direct-reading, single-indicating column. Dotted lines indicate fluid level when pressure is applied to reservoir. (C) slant tube type expands the range of the scale. There are more graduations for one in. of vertical height and it is easier and more accurate to read.

Manometers—Theory and Application

From: Company Bulletin

Simple, low cost instrument for the measurement of any quantities that are a function of pressure. Designed primarily as a laboratory instrument, they are now finding many industrial uses.

A manometer provides a simple solution to complex measurement problems; it assures a high degree of sensitivity, indicating the slightest variation in pressure. Any variable that is a function of pressure or that can be interpreted in terms of pressure can be measured. Flow, vacuum, liquid level, draft are all functions of pressure and are measureable in in., lb, gpm.

Principle is simple. If the pressure is greater than atmospheric, the liquid is forced downward in the leg to which the pressure source is connected and upward in the open leg. The amount of pressure applied is measured by the difference in fluid height in the two legs.

Manometer types are shown in Fig. 1. U configuration is basic and the well and slant tube are modifications.

MANOMETER APPLICATIONS

Some manometer applications are differential gage pressure, flowmeter, gas meters, tank gages, specific gravity indication, and inter-face identification.

Differential gage pressure. Manometer affords the highest degree of accuracy—0.02 in.—and sensitivity in the measurement of pressure differentials up to 120 inches of mercury. All types can be used for this measurement with selection based on maximum range and sensitivity required. Instruments measured differentially across filters, heat exchangers and other allied equipment.

Flowmeter. As a pressure sensing device in a flowmeter system, the manometer is highly versatile, Fig. 2. High accuracy, sensitivity and reproducibility are possible.

A special form of flowmeter uses a manometer coupled with a pitot tube to test centrifugal, axial, and propeller fans, Fig. 3. Normally, a manometer with a tube bore of 0.250 in. or greater and a liquid having a specific gravity of less than 1.00 is specified. Slant tube type is ideal since high accuracy and sensitivity are required.

For precise "on-off" flow control a contactor manometer can be used. Instrument consists of a standard manometer which has adjustable electrical contacts to sense discrete levels of the manometer fluid. The fluid must be a good conduction with good chemical stability.

Fuel meters. A slant tube manometer is used, with water or mercury as the fluid, to check gas meters. Differential measurements will locate the existance of binds and incorrect valve settings. The unit can also be used to study pressure drop in low pressure gas distribution systems.

A calibration system for fuel flowmeters has a special manometer for its sensing system. It is used in a system handling 50-60,000 lb/hr and can check to within plus or minus 0.1% of meter scale reading.

Liquid is pumped during measured time intervals into a vertical standpipe of precise known uniform diameter. Connected to the base of the standpipe is a mercury manometer. The mercury level rises with increasing pressure of liquid in the standpipe. Because the pressure at the base of the standpipe depends directly on the weight of the liquid, each mercury level in the manometer corresponds to a specific liquid weight. The weight of the collected liquid is the product of the pressure at the base and the cross-section area of the standpipe.

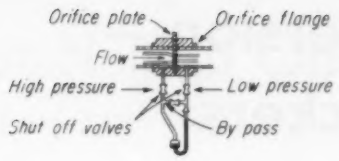


Fig. 2

Fig. 2—Flowmeter application of manometer. Cost advantage is low for small bore sizes but increases as pipe size increases.

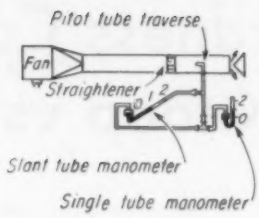


Fig. 3

Fig. 3—Centrifugal fan application. Single manometer installation may be used, or two, as shown, for checking purposes.

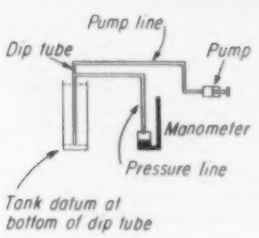


Fig. 4

Fig. 4—Intermittent purge liquid level system. Pump introduces known amount of fluid into tank for simple measurement.

This weight is independent of the liquid density just as if it had been obtained by actual weighing on a scale. By taking into account the time interval for collecting any given weight of liquid, the mass rate of flow is obtained directly. There is no system lags or accelerations from friction or inertial effects that can arise from the stop and start movement of large masses.

Manometer-type flowmeters are used to measure air flow in air conditioning and ventilation systems. Air delivered to foundry cupolas and to blast furnaces is also accurately measured with manometers.

Tank gages. A manometer can be used to measure the quantity of stored liquids in both closed and open tanks. Height or volume is measured by balancing the head of tank liquid contents with a head of manometric fluid of a known density. Head metering involves direct contact with the tank liquid contents and is the cheapest and simplest gage available.

The purge balance method involves the introduction of regulated instrument air, inert gas, or liquid into the storage tank. It may be intermittent or continuous depending on the installation, Figs. 4 and 5. This type gage is used in bulk storage of gasoline, oil, alcohol, thinners, and solvents. In marine service, quantities of fuel oil, lube oil, fresh water and ballast are measured. The chemical industries, with their volatile, foaming and corrosive liquids, use manometers as a safe and accurate means of level measurement.

Specific gravity indication. The chemical and food processing industries use manometer-type specific gravity indicators. A simple modification of the tank gaging system consisting of the two purge points spaced 10 inches apart in a liquid to be measured, Fig. 6, will give an indication accurate to three significant places.

Connection is made from the bottom purge outlet to the high pressure connection of the manometer; the upper purge outlet is connected to the low pressure side of the manometer. The precisely known distance between the two purge outlets identifies the base gravity point on the manometer scale. Scale graduations cover the entire range of specific gravities expected.

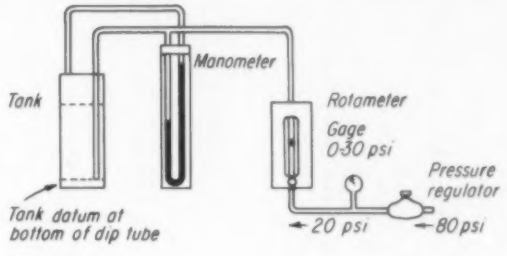


Fig. 5

Fig. 5—Constant purge liquid level system. Air, inert gas, or liquid is continually introduced into the tank at a known rate.

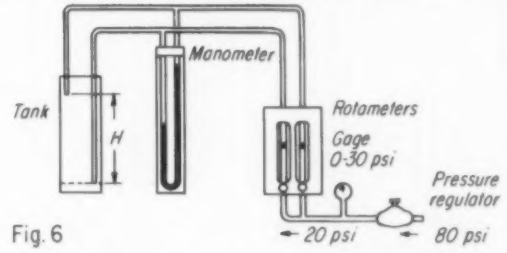


Fig. 6

Fig. 6—Constant purge density system. Modified tank gage system add second purge system at a known distance from original.

Inter-face identification. The problem of identifying the inter-face of two immiscible fluids is prevalent in the petrochemical industry. A manometer installation similar to the one for specific gravity indication is used. Each inch movement of the interface is indicated by a change in head pressure equal to the difference in specific gravity but graduated on the scale in fractions of an inch. The only requirement for consistent accuracy is a positive location of the upper purge outlet at or below the maximum height of the inter-face to be measured.

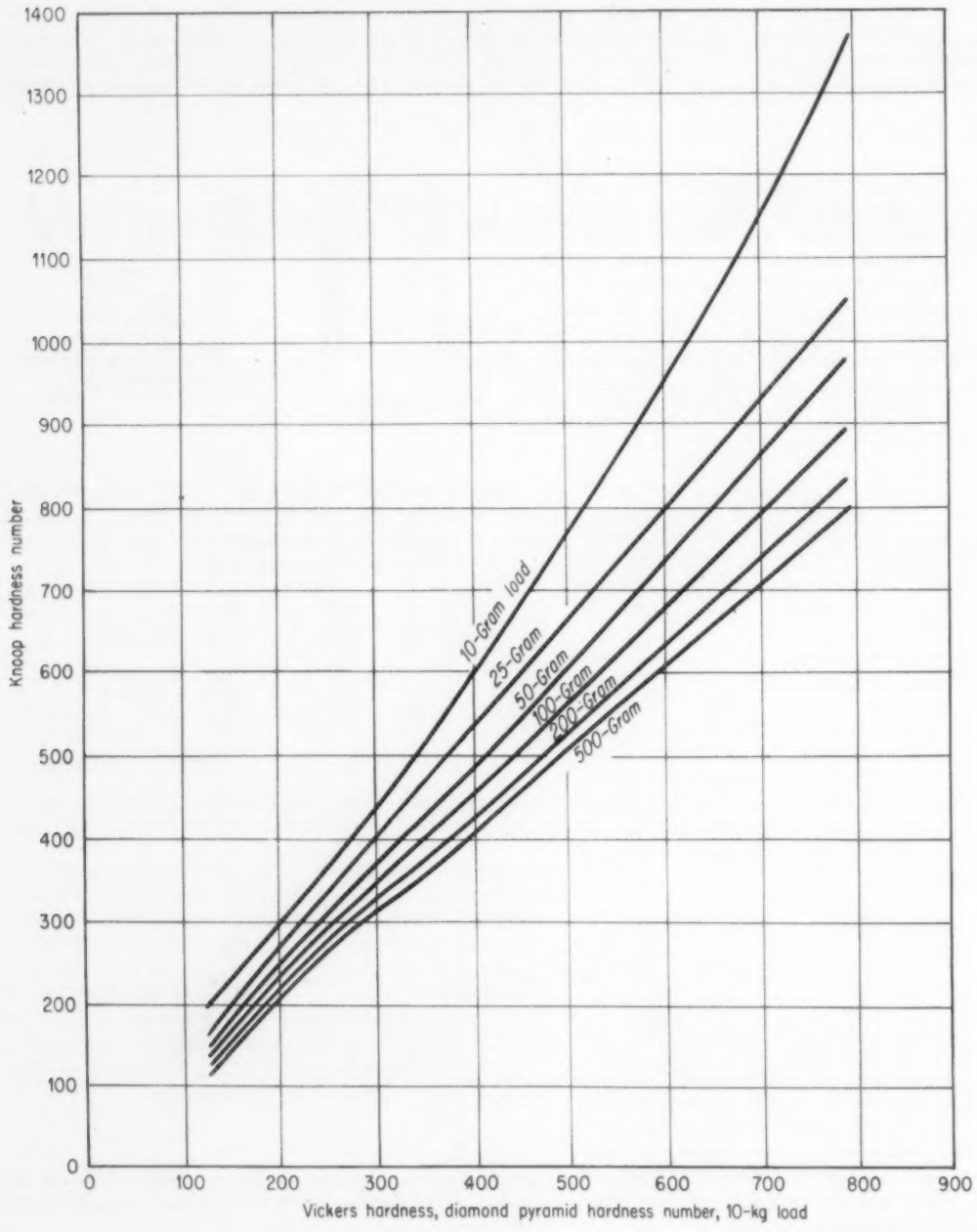
REFERENCE:
Manometers, Theory and Application. Published by the Dynametrics Corporation, Northwest Industrial Park, Burlington, Massachusetts.

From: Metal Progress

Hardness Conversion — Knoop vs Vickers

LLOYD EMOND
Metallurgical Research Dept.
A. O. Smith Corporation

REFERENCE:
Hardness Conversions, Knoop Versus Vickers by Lloyd Emond, Metallurgical Research Department, A. O. Smith Corporation, Milwaukee, Wisconsin. Published in Metal Progress, September, 1958, p 96B-97.



Selecting Control Devices for Human Operators

GEORGE A. PETERS
STAN MICHELSON
Psychological Research Associates, Inc.

From: Control Engineering*

This simplified chart is intended as a design guide. While only the more common control devices are listed, others may be more appropriate for certain applications due to design peculiarities.

* Published in Control Engineering, March 1959, p 127.

Task Requirements	Task Examples	Control Devices	Common Applications	Necessary Design Features for Manual Control Devices	Human Factors in Application of Manual Control Devices
Selection Between Two Alternatives	System activation	Toggle switch (two-position only)	Equipment ON—OFF, or subsystem START—STOP	Flip type, definite snap action contact, sufficient lever displacement for easy visual identification of position.	Vertical orientation preferred. ON position should always be UP or to the RIGHT. Use a green pilot light to indicate when circuit is energized. Switch should move toward light to the ON position.
	Momentary contact—high frequency of use	Pushbutton type (A) push = on, release = off	Signal button or typewriter key	Should be color-coded as necessary. Should have a definite feel and audible click when circuit is activated. Concave surface to reduce finger slipping and irritation with continued use. Low force and high pretravel are usually desirable.	Emergency stops should be red and 1 in. minimum diameter. Flush or recessed mounting recommended to reduce accidental activation.
	Extended contact	Pushbotton type (B) push-release = on push-release = off	Foot or elbow pushbutton		
	"Lock-on" contact	Pushbutton type (C) push-release = on another button push-release = off	Motor start switch		
Selection Between Three or More Control Positions	Channel selection	Rotary selector switch	Function selector or range switch	Mechanical end-stops and detents with an audible click to aid in positioning. The number of positions should be minimum (never over 24). Pointers should be tapered and short to reduce reading errors.	Clockwise movement should result in numerical increase. No switch position should be located 180 deg. from another position, since this increases the chance of erroneous readings.
Precise Adjustment Over a Wide Range	Align, change, or adjust a continuous variable	Knob	Tuning controls, zeroing gain controls, zeroing or null controls	Small knobs should be knurled. Large knobs should have pointed serrations. All knobs should be secured by two set-screws.	Knobs should be below or to the right of scales, and on the concave side of curved scales. Indicator pointers should minimize perceptual parallax.
	High rate of turning over large distance	Crank	Manual tracking controls	Grip handles should rotate about their own axes (spinner handles).	Clockwise rotation should result in an increase in the controlled function.
Force Application	Foot activation	Pedal	Braking or steering controls	Spring should support weight of foot in null position. Pedal should return to null position when force is removed. Non-skid surface for face of pedal.	Used to unburden hands for prolonged force application. Not more than two pedals for each foot.
	Rapid linear displacement or multidimensional movement	Lever	Combination direction and rate controls	Lever handles should be shape-coded. Lever arm displacement arc should not be greater than 90 deg. and should permit convenient arm reach.	Should be located on median plane of body or in front of activating arm. Elbow, forearm, or wrist supports should be provided. Detents for discrete adjustments.
	Rotary forces, slow rate of turn: (A) Two-handed force application with continuous vigilance or feedback (B) Two-handed force application without feedback (C) One-handed force application	Handwheel	(A) Steering wheels (B) Very large valves* (C) Small valves	For two-handed vigilance operations, the operating arc should be less than 120 deg. The gripping surface should be indented or knurled. A spinner handle may be added for whirling. The handwheel may be combined with pushbutton controls. *NOTE: Valves conventionally turn clockwise for OFF or CLOSE. This is contrary to the general principle for control-display relationships. Furthermore, such valve action may increase or decrease the function or process affected. Therefore, it is vitally important to adequately label all valves.	Clockwise direction of handwheel should be associated with an increase in the visual display (dial) or function, EXCEPT FOR VALVES*. For vigilance tasks, no portion of handwheel should interfere with the operator's vision.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(A-1) Dispenser—Brochure, 4 pp. Describes strapping tape applicators, lists advantages of portable, hand-operated machines. Illustrates typical applications of strapping tapes. Permacel-Lepage's, Inc, New Brunswick, NJ.

(A-2) Instruments for Data Reduction—Catalog, 13 pp. Brief description of instrument, technical information, sample applications, ordering information. The Gerber Scientific Instrument Co, 89 Spruce St, Hartford, Conn.

(A-3) Aperture Cards—Brochure, 16 pp. Describes use of microfilmed engineering drawings inserted in aperture cards for reference and reproduction. Gives techniques for microfilming drawings, filing film in cards, use of cards with readers and enlargers. The Filmsort Co, Div Miehle-Goss-Dexter, Inc, Pearl River, NY.

(A-4) Unitized Microfilm Systems—Folder, 8 pp. Describes the modern system of engineering drawing reproduction utilizing microfilm, aperture cards. Copies by means of dry, automatic, xerographic printer reproducing drawings up to 24 x 36 inches in 10 seconds. Haloid Xerox Inc, 2-20 Haloid St, Rochester, NY.

(A-5) Automatic Air and Gas Dryer—Bulletin, 4 pp. Describes new type of automatic air and gas dryer capable of controlling dew point of gases. Dew points lower than 100 F can be maintained. United States Dynamics Corp, 1250 Columbus Ave, Boston 20, Mass.

(A-6) Camera Turret—Brochure, 4 pp. A simple, self-contained unit installed on the camera which constantly moves the TV camera lens in a small circle causing the picture to always be in motion and thus eliminating image orthicon tube sticking. Visual Electronics Corp, 356 W 40 St, NY 18, NY.

(A-7) Galvanometers—Catalog, 16 pp. Specifications for choosing proper solid frame and sub-miniature galvanometers for use with direct-recording oscillographs. Curves, charts, other detailed data. Heiland Div, Minneapolis-Honeywell Regulator Co, 5200 E Evans Ave, Denver 22, Colo.

(A-8) Bridge Balance and Strain Indicator Unit—Catalog, 4 pp. Specifications, ordering information for unit which permits calibrating and measuring static and dynamic phenomena from resistance-type transducers or gages. Heiland Div, Minneapolis-Honeywell Regulator Co, 5200 E Evans Ave, Denver 22, Colo.

(A-9) Vises—Catalog, 4 pp. Shows sizes, prices, applications and advantages. Illustrated with photographs. Emmert Mfg Co, Box 488, Waynesboro, Pa.

(A-10) Oscillographs—Bulletin, 16 pp. Complete description and specifications of 8- and 14-channel direct-recording visicorder oscillographs; ordering information. Heiland Div, Minneapolis-Honeywell Regulator Co, 5200 E Evans Ave, Denver 22, Colo.

(A-11) Amplifier Systems—Catalog, 8 pp. Specifications, illustrations, applications of amplifier systems for static and dynamic oscillographic recording. Both carrier and linear/integrate systems. Heiland Div, Minneapolis-Honeywell Regulator Co, 5200 E Evans Ave, Denver 22, Colo.

(A-12) Data Reduction Equipment—Catalog, 60 pp. Describes function and operation of data reduction systems and allied equipment. Data Instruments Div of Telecomputing Corp, 12838 Saticoy St North Hollywood, Calif.

(A-13) Telemetering Equipment—Brochure, 5 pp. Describes and illustrates telemetry systems for aircraft and missile applications. Lists components, performance statistics and test data. Bendix-Pacific Div, Bendix Aviation Corp, 11600 Sherman Way, North Hollywood, Calif.

(A-14) Profilometer—Catalog, 14 pp. A complete line of instruments for the measurement and control of surface finish in microinches either rms or arithmetical. Micrometrical Mfg Co, 345 S Main St, Ann Arbor, Mich.

(A-15) Analog Computer—Catalog, 16 pp. Design and construction features of computer and operational components. Specifications for amplifiers, servos, multipliers, function generators, power supplies and auxiliary equipment. Reeves Instrument Corp, Garden City, NY.

(A-16) Thermostats and Thermol Controls—Bulletin, 2 pp. Describes a complete line of miniature, hermetrically sealed, and capsule type units. George Ulanet Co, 413 Market St, Newark, NJ.

(A-17) Fire Protection Equipment—Catalog, 16 pp. Describes complete line of portable extinguishers, fire and smoke detection equipment and built-in carbon dioxide systems. Walter Kidde & Co, Inc, 669 Main St, Belleville 9, NJ.

(A-18) Packaging Machines—Catalog, 11 pp. High speed machines for automatically applying pre-cut cellulose neck bands. Their features, specifications, operation and accessories are illustrated and explained. Gisholt Machine Co, 1245 E Washington Ave, Madison 10, Wis.

(A-19) Scales—Catalog, 84 pp. Contains literature and information on various models of weighing machines, auto, checkweighing and sacking scales. The Exact Weight Scale Co, 538 E Town St, Columbus, Ohio.

(A-20) Planfiles—Catalog, 16 pp. Shows space and time-saving advantage of filing engineering drawings, blueprints, and others, vertically. Construction features and accessory equipment illustrated. Art Metal Construction Co, Jones & Gifford Ave, Jamestown, NY.

(A-21) Pressure Protective Devices—Brochure, 2 pp. Describes devices for protecting pressure sensitive instruments from excessive stresses. Covers from minus 15 psig to 9000 psig. Industrial Engineering Corp, 525 E Woodbine, Louisville 8, Ky.

(A-22) Electric Interval Timers—Catalog, 2 pp. Describes timers with ranges of 60 seconds to 60 hours for panel mounting. Dimco-Gray Co, 207 E 6th St, Dayton 2, Ohio.

(A-23) Lighting—Catalog, 33 pp. Describes and illustrates industrial localized lighting equipment giving available types, specifications and other pertinent data. The Fostoria Pressed Steel Corp, 1200 N Main St, Fostoria, Ohio.

(A-24) Drafting Desk—Brochure, 8 pp. Describes the seated drafting operation and the various models and arrangements that are available. The General Fireproofing Co, Youngstown 1, Ohio.

(A-25) Laboratory Test Equipment—Catalog, 4 pp. Lists electronic test equipment available for phase and voltage measurement. Acton Laboratories Inc, 533 Main St, Acton, Mass.

(A-26) Balancing Machines—Catalog, 36 pp. The nature of balancing is defined and discussed. The unit, forces, causes of unbalance, types and principles of operation for various pieces of equipment is also covered. Gisholt Machine Co, 1245 E Washington Ave, Madison 10, Wis.

(A-27) Ceiling Tiles and Interior Finishes—Catalog, 8 pp. Describes complete line of acoustical, decorator and regular ceiling tile plus roof deck. Wood Conversion Co, First National Bank Bldg, St Paul, Minn.

(A-28) Drafting Room Furniture and Equipment—Catalog, 32 pp. Gives sizes, dimensions, and shipping weights of drafting tables in wood or steel and accessories. Mayline Co, Inc, Sheboygan, Wis.

(A-29) Pressure-sensitive Tape Dispenser—Brochure, 1 pp. Tape dispensers for filiment, strapping, drafting, electrical packaging, double coated liner wound, and single coated tapes. Trade Aid Supplies Co, 1316 E 24 St, Minneapolis 4, Minn.

(A-30) Structures and Containers—Brochure, 6 pp. Describes the basic principles, its advantages and applications. Engineering information and test results are available. Lindsay Structure Div of International Steel Co, 1321 Edgar, Evansville, Ind.

(A-31) Temperature Controls—Catalog, 8 pp. Complete specifications, dimensions and construction details on precision controls. Also includes accessories and ordering information. Fenwal Inc, Pleasant St, Ashland, Mass.

(A-32) Digital Readout Counters—Catalog, 8 pp. Describes digital readout counters for all types of electronic and mechanical applications where numerical reading is required. Durant Mfg Co, 1938 N Buffum St, Milwaukee, Wis.

(A-33) Centralized Transport Control Systems—Bulletin, 4 pp. Describes concept of automatic pipeline control from a central location with high degree of reliability. Typical problems encountered in transport control are reviewed and systems are recommended for particular applications. Union Switch & Signal, Div of Westinghouse Air Brake Co, Pittsburgh 18, Pa.

(A-34) High-pressure Gages—Brochure, 4 pp. Custom design high pressure gages for jet aircraft, missiles, missile test stands and commercial applications. Rochester Mfg Co, Inc, 214 Rockwood St, Rochester 10, NY.

(A-35) Platinum Temperature Transducers—Catalog, 4 pp. Describes types and models of precision resistance thermometers for measurement of liquid, gas, and surface temperatures. Gives accuracies, ranges, and installation data. Trans-Sonics, Inc, PO Box 328, Lexington 73, Mass.

(A-36) Flat Lead Holder—Brochure, 6 pp. Illustrates and describes flat lead drawing holder for designers, engineers and draftsmen. Explains operation and use of holder, flat shaped drawing lead it employs and the advantages for lofting of all large area drawing. A W Faber-Castell Pencil Co, Inc, 41-47 Dickerson St, Newark 3, NJ.

(A-37) Magnetic Particle Testing Unit—Brochure, 4 pp. Discusses new equipment available for rapid production testing of nonferrous parts up to 24 in. in length. Describes types of magnetizing current, circular and longitudinal magnetization, continuous current features, inspection medium, and various accessories available. Magnaflux Corp, 7300 W Lawrence Ave, Chicago 31, Ill.

(A-38) Instrument Mountings—Catalog, 2 pp. Listing of features, construction and applications as well as dimensional data. Bushings, Inc, 4358 Coolidge Hwy, Royal Oak, Mich.

(A-39) Machine Lights—Catalog, 6 pp. Standard localized lighting fixtures for OEM application to machine tools, business machines, recorders, instruments, production equipment and others. Stocker & Yale Inc, 40 Green St, Marblehead, Mass.

(A-40) Filament Strain Gage—Catalog, 24 pp. A complete listing of over 250 bonded filament, resistance strain gages, including specifications, prices, outline drawings and application information. Baldwin-Lima-Hamilton Corp, E & I Div, 42 Fourth Ave, Waltham 54, Mass.

(A-41) Temperature Controls—Catalog, 4 pp. Covers general construction and operation; includes pictures and brief description of all standard differential expansion models of thermostats, temperature controls and alarms. Burling Instrument Co, 16 River Rd, Chatham, NJ.

(A-42) Counting Devices—Catalog, 4 pp. Condensed catalog of mechanical, electro mechanical and electronic counters for all counting requirements. Veeder-Root Inc, Hartford 2, Conn.

(A-43) Ultrasonic Reflectoscope—Bulletin, 8 pp. Describes briefly the principal of ultrasonic inspection, typical applications, available services and instruments. Sperry Products, Inc, Shelter Rock Rd, Danbury, Conn.

(A-44) Flooring—Catalog, 2 pp. Photographs and description of novel type of matting for floors, cars, boats, kitchens and factory mats. Emeloid Mfg Co, 1239 Central Ave, Hillside 5, NJ.

(A-45) Tabulating Card Punch—Brochure, 4 pp. A portable tabulating card punch which produces original data at source in finished form. Uses standard IBM or Remington Rand cards. Punches every card position. PDP Div of American Electronics, Inc, 75 Front St, Brooklyn, NY.

(A-46) Reproduction Materials and Equipment—Catalog, 52 pp. Describes materials and equipment used for creation and reproduction of engineering drawings, plant layout, parts lists and similar technical data. Tecnifax Corp, 195 Appleton St, Holyoke, Mass.

(A-47) High-temperature Control Units—Catalog, 4 pp. Automatic, self-contained temperature control units to circulate and to regulate the temperature of a heat transfer fluid from room temperature to 500-550 F. Sterling, Inc, 5200 W Clinton Ave, Milwaukee 18, Wis.

(A-48) Thermometers—Bulletin, 8 pp. A complete line of adjustable piping and duct thermometers. Jas P Marsh Corp, 3501 Howard St, Skokie, Ill.

(A-49) Etched Foil Strain Gages—Bulletin, 6 pp. Lists and describes all standard foil gage types; includes characteristics, features, temperature ranges and prices. Baldwin-Lima-Hamilton Corp, Electronics & Instrumentation Div, 42 Fourth Ave, Waltham 54, Mass.

(A-50) Penetrant Dye—Bulletin, 5 pp. Describes and illustrates the penetrant dye flaw finding process; gives instructions for use and ordering data. The Met-L-Chek Co, 11919 S Western Ave, Los Angeles 47, Calif.

(A-51) Recorder—Catalog, 3 pp. Describes the advantages, features and specifications of a channel recorder and the rectilinear, ink writing penmotor. Massa Div of Cohu Electronics, Inc, 5 Fottler Rd, Hingham, Mass.

(A-52) Pressure Transducers—Bulletin, 4 pp. Describes construction and applications for precise measurement of static and dynamic pressures. American Radiator & Standard Sanitary Corp, Norwood Controls Unit, Detroit Controls Div, 934 Washington St, Norwood, Mass.

(A-53) Drafting Machine—Bulletin, 8 pp. Track graduations provide equivalent of precise 10 inch drawing grid. Standard mechanical or civil engineer protractor. Automatic balancing at any angle. Made for any length board. Used for original design, layout, and all large or exact drawings. Universal Drafting Machine Corp, 7960 Lorain Ave, Cleveland 2, Ohio.

(A-54) Temperature Control Systems—Catalog, 22 pp. Describes miniaturized sealed control box, electronic control, cooling effect detector systems, electronic control box, remote adjustable thermostat and metal clad temperature sensing elements. Barber-Colman Co, Aircraft Controls Div, Rock St, Rockford, Ill.

(A-55) Synchro Test Equipment—Brochure, 6 pp. Contains chart showing the equipment used, synchro test procedures, definitions, test diagrams, accuracy, volttage and insulation resistance of various models. Kearfoot Co, Inc, 1500 Main Ave, Clifton, NJ.

(A-56) Pyrometers—Catalog, 8 pp. Describes optical, micro-optical, radiation, surface, immersion and indicating pyrometers. Gives model numbers, specifications, and engineering information. Pyrometer Instrument Co, Inc, 92 Portland Ave, Bergenfield, NJ.

(A-57) Test Equipment—Catalog, 16 pp. Flow velocity and temperature sensing probes with calibrations, remote controlled positioners and mercury stop rings are described. Flow equations included. United Sensor & Control Corp, 122 Naubuc Ave, Glastonbury, Conn.

(A-58) Sight Flow Indicator—Bulletin, 4 pp. Describes construction; gives sizes, flow ranges, field adjustment instructions; lists applications and dimensions. McIntosh Equipment Corp, Walker Crosweller Div, 15 Park Row, NY 38, NY.

(A-59) Thermocouples—Brochure, 8 pp. Describes various designs and uses of ceramic insulated thermocouples. Also, termination adapters and typical applications. Aero Research Instrument Co, 315 N Aberdeen St, Chicago 7, Ill.

(A-60) Logic Unit Board—Brochure, 8 pp. Describes a transistorized digital component from which computers and data handling systems can be constructed. Mechanical Div of General Mills, Inc, 1620 Central Avenue NE, Minneapolis 13, Minn.

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(A-62) **Transparencies**—Brochure, 4 pp. Description of adhesive transparencies and illustrations of possible new uses in drafting Stanpat Co, 150-42 12th Rd, Whitestone 57, NY.

(A-63) **Meters and Controls**—Bulletin, 8 pp. Describes measuring, transmitting, receiving, recording, and indicating instruments and control components. Bailey Meter Co, 1050 Ivanhoe Road, Cleveland, Ohio.

(A-64) **Sensing Devices**—Catalog, 16 pp. Describes various methods and components available for the collection of data to determine vibration, pressure, acceleration or similar parameters. Transducer Div, Consolidated Electrodynamics Corp, 300 N Sierra Madre Villa, Pasadena, Calif.

(A-65) **Spray Paint and Masking Supplies**—Brochure, 6 pp. Lists overlapping spray masking disks, extra narrow tape, plugs, caps, corks, and printed circuit drawing aids. By-Buk Co, 4314 W Pico Blvd, Los Angeles 19, Calif.

(A-66) **Office Equipment**—Catalog, 19 pp. Describes various pens, carbon papers, template lacquers and developers, and photocopy devices. Includes data on standard sizes, prices and materials. Ozalid Div, General Aniline and Film Corp, Johnson City, NY.

(A-67) **Office Copying Machines**—Brochure, 8 pp. Describes processes used by various machines; gives advantages and disadvantages of each. Copease Corp, 425 Park Ave, NY 22, NY.

(A-68) **Pressure Measurement Instruments**—Catalog, 12 pp. Describes operating principles, available scales and dimensions of U form, fixed and sliding scale manometers. Trimount Instrument Co, 3119 W Lake St, Chicago 12, Ill.

(A-69) **Gas Thermostatic Controls**—Brochure, 4 pp. Gives features, uses and mounting descriptions for controls. The Wilcolator Co, 1001 Newark Avenue, Elizabeth, NJ.

(A-70) **Testing Services**—Bulletin, 6 pp. Describes engineering services and facilities including: environmental studies, electronics, instrument calibration, reliability testing; chemicals laboratory; materials testing and others. United States Testing Co, Inc, 1415 Park Ave, Hoboken, NJ.

(A-71) **X-ray Processor**—Brochure, 6 pp. Describes high-speed processor for industrial x-ray film giving specifications and model information. Eastman Kodak Co, 343 State St, Rochester 4, NY.

(A-72) **Detectors**—Brochure, 4 pp. Describes and illustrates various types of infrared detectors. Eastman Kodak Co, 343 State St, Rochester 4, NY.

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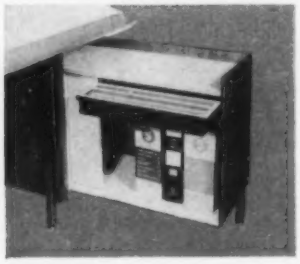

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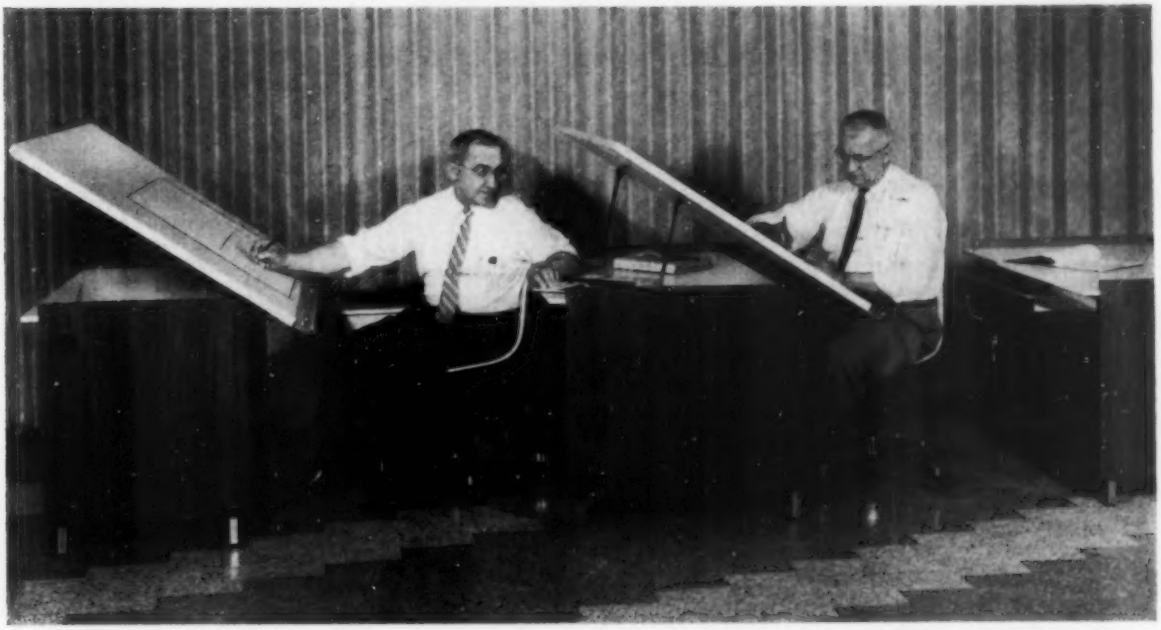

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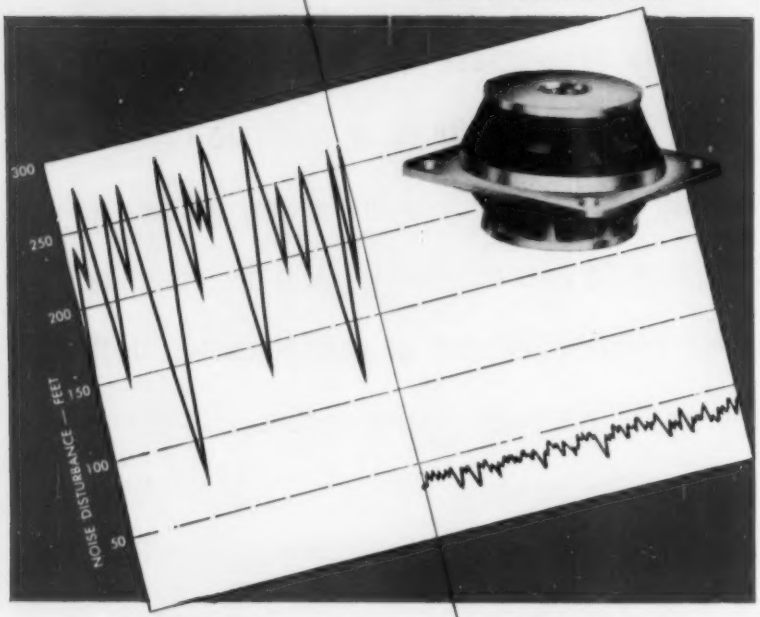

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(A-73) Minicard System—Brochure, 6 pp. Describes system and equipment used for electronic-microfilm medium for the unit record storage and single-search retrieval of documentary information. Recordak Corp, Div Eastman Kodak Co, 415 Madison Ave, NY 17, NY.

(A-74) Pressure Gages—Catalog, 36 pp. Lists line of gages which are suitable for various industrial, processing and chemical applications. Also included: types of systems, applications, dimensional drawings, specifications, accessories and ordering information. Helicoid Gage Div, American Chain & Cable Co, Inc, Bridgeport 2, Conn.

(A-75) Drafting Instruments—Catalog, 4 pp. Photographs, features, sizes and applications of various instruments. Emmert Mfg Co, Box 488, Waynesboro, Pa.

(A-76) Electric Vehicles—Brochure, 6 pp. Describes specifications, operating and maintenance costs of line of vehicles with electric motive power and their applications. Cushman Motors, Lincoln, Neb.

(A-77) Counting Instruments—Catalog, 4 pp. Summary of electrical and mechanical counting instruments together with actuating switches designed for electric counters. Production Instrument Div, General Controls Co, 8080 McCormick Blvd, Skokie, Ill.

(A-78) Drafting Equipment—Catalog, 4 pp. Contains illustrations and explanations of components, drawing board sizes and specifications. Emmert Mfg Co, Box 488, Waynesboro, Pa.

(A-79) Aluminum Knobs—Brochure, 2 pp. Describes engraving, color, sizes and styles of knobs. Pacific Transducer Corp, 11836 W Pico Blvd, Los Angeles 64, Calif.

(A-80) Optical Instruments—Catalog, 12 pp. Contains specifications, working lengths, applications and ordering information. Engelhard Industries, Inc, 113 Astor St, Newark, NJ.

(A-81) Drafting Machines—Catalog, 8 pp. Description of units with illustrations, prices, specifications and available accessories. Universal Drafting Machine Corp, 7960 Lorain Ave, Cleveland 2, Ohio.

(A-82) Drafting Machine Scales—Brochure, 6 pp. Illustrates models and features. Universal Drafting Machine Corp, 7960 Lorain Ave, Cleveland 2, Ohio.

(A-83) Instrument Protection Devices—Catalog, 8 pp. Contains engineering data, charts, description and application information on devices for gage protection. Chemiquip Co, 36 E 10th St, NY 3, NY.

(A-84) Nameplates and Adhesive Backings—Bulletin, 4 pp. Describes different types of permanent adhesive backings on anodized aluminum foil nameplates. Specifies correct adhesive for problem surfaces and installation methods. Park Nameplate Co, 34-10 Linden Place, Flushing, NY.

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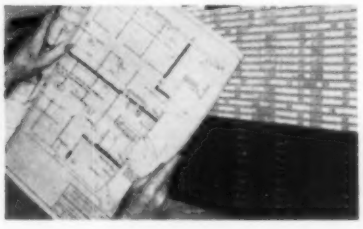

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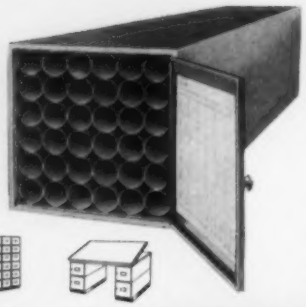

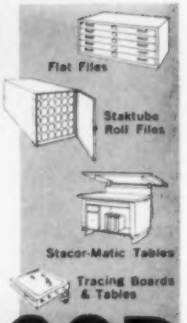

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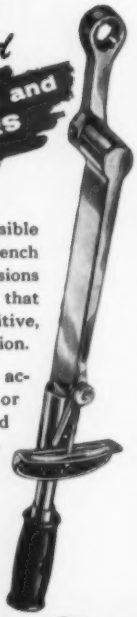

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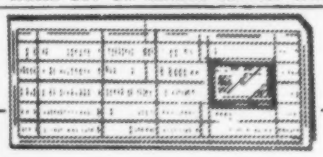

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(A-85) Commercial Thermostats—Catalog, 39 pp. Gives specifications, description, dimensional drawings, operation, electrical ratings, and ordering information of the fixed temperature type for commercial applications. Metals & Controls Corp, Versailles Products Div, 300 N Main St, Versailles, Kentucky.

(A-86) Surface Flatness Tester—Brochure, 4 pp. Explains operation, capabilities and application of quality control device. Specifications, advantages and sales information are also listed. Cartriseal Corp, 3515 W Touhy Ave, Lincolnwood, Ill.

(A-87) Counting Devices—Catalog, 46 pp. Pictures, outline drawings and specifications of counting devices. Bowmar Instrument Corp, PO Box 2835, 8000 Bluffton Rd, Fort Wayne, Ind.

(A-88) Timing Devices—Bulletin, 14 pp. Lists motors, speeds, electrical characteristics, mechanical properties, physical dimensions and applications. Haydon Div of General Time Corp, 245 E Elm St, Torrington, Conn.

(A-89) Unmounted Optical Parts—Catalog, 14 pp. Specifications, drawings and prices for condensers, lenses, prisms and reflectors. Also contains selection and ordering information. Bausch & Lomb Optical Co, 635 St Paul St, Rochester 2, NY.

(A-90) Automatic Controls—Brochure, 16 pp. Describes facilities and engineering service available for automatic coin collection, high speed data processing, production line automation equipment and others. North Electric Co, 553 S Market St, Galion, Ohio.

(A-91) Movable Steel Partitions—Catalog, 20 pp. Pictures, details and description of 2 in. thick flush moveable partition consisting of 12 in. wide panels of laminated steel and paper honeycomb core. Steel Partitions Inc, PO Box 807, Jamestown, NY.

(A-92) Automatic Controls—Catalog, 60 pp. Controls for pressure, temperature, liquid level, mechanical movement, relays, mercury switches. Includes operating ranges, applications and prices. The Mercoid Corp, 4201 Belmont, Chicago 41, Ill.

(A-93) Reproduction Process and Machines—Brochure, 12 pp. Describes principles, features, and applications of the whiteprint reproduction process. Includes description of machines and materials. Charles Bruning Co, Inc, 1800 W Central Rd, Mt Prospect, Ill.

(A-94) Drawing Templates and Supplies—Catalog, 48 pp. Includes illustrations and prices of slide rules, templates, grids and others. Alvin & Co, Inc, Windsor, Conn

(A-95) Electric Impulse Counters—Bulletin, 12 pp. Contains connection diagrams, specifications, ratings and dimension drawings for various models. Landis & Gyr, Inc, 45 W 45th St, NY 36, NY.

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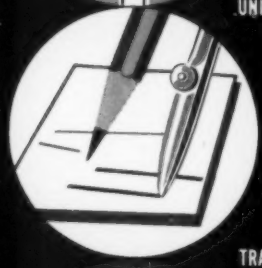

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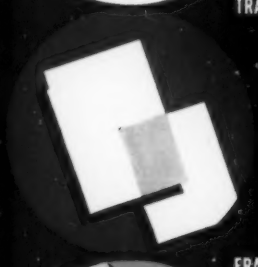

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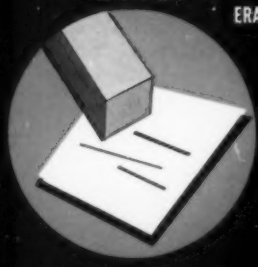

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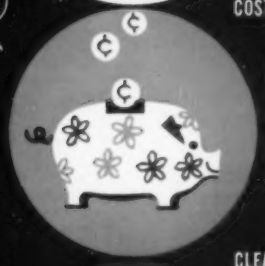

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catalogs and bulletins.....continued

(A-96) **Drafting Templates**–Catalog, 16 pp. Describes and illustrates drafting templates for designers, engineers and draftsmen. Includes prices. Rapidesign, Inc, Box 429, Burbank, Calif.

(A-97) **Material Handling Equipment**–Catalog, 68 pp. Presents descriptions, engineering data and specifications together with photographs and sales information. Syntron Co, 240 Lexington Ave, Homer City, Pa.

(A-98) **Clock Movements**–Bulletin, 8 pp. Describes clock movements and fitups, both eight day and electric; gives ordering information. The E Ingraham Co, Bristol, Conn.

(A-99) **Density Measurement System**–Bulletin, 12 pp. Describes components of system which present specific gravity, percent solids, or other density measurements without interfering with flow in pipes ranging from 3 in. to 8 in. in diameter. Lists applications and describes construction and operation. Industrial Nucleonics Corp, 1205 Chesapeake Ave, Columbus, Ohio.

(A-100) **Ray Control Systems**–Bulletin, 8 pp. Describes applications, construction, specifications and other engineering information on externally mounted bin and tank level systems. Industrial Nucleonics Corp, 1205 Chesapeake Ave, Columbus, Ohio.

(A-101) **Drafting Equipment**–Catalog, 34 pp. Photographs, layout suggestions, dimensions and specifications for drafting tables, plan files and their accessories. Price list is attached. Hamilton Mfg Co, 18th St, Two Rivers, Wisc.

(A-102) **Record Files**–Brochure, 8 pp. Gives description of uses, advantages and available size of interlock roll record files. Hamilton Mfg Co, 18th St, Two Rivers, Wisc.

(A-103) **Thickness Gage**–Catalog, 32 pp. Description of thickness guaging apparatus complete with operating tables, specifications, applications, outline drawings, and selection table. Tracerlab, Inc, 1601 Trapela Rd, Waltham, Mass.

(A-104) **Pressure Gages**–Catalog, 48 pp. Gives construction specifications, applications, operation, charts and ordering information for all models. Kunkle Valve Co, 121 S Clinton St, Fort Wayne 2, Ind.

(A-105) **Ground Handling Equipment**–Brochure, 4 pp. Description of approved caster assemblies, parking brakes, cushion tread wheels and undercarriage components for ground support and handling equipment. Aerol Co, Inc, 3235 San Fernando Rd, Los Angeles, Calif.

(A-106) Nuclear Instrumentation–Catalog, 137 pp. Describes line counting, radiation analysis and monitoring equipment as well as other products in the radiation field. Contains photographs and specifications for various models. Tracerlab, Inc, 1601 Trapela Rd, Waltham, Mass.

(A-107) **Signal Devices**–Catalog, 13 pp. Describes bells, horns and chimes for audible signalling in buildings or on control units. Gives dimensions, ac and dc characteristics and ordering information. Wheelock Signals, Inc, 273 Branchport Ave, Long Branch, NJ.

(A-108) **Temperature Controls**–Catalog, 6 pp. Describes local mounted and remote bulb models for industrial, aircraft, marine and special purpose application. Brief specification and price information is also included. United Electric Controls Co, 85 School St, Watertown, Mass.

(A-109) **Drawing Ink Fountain Pen**–Brochure, 6 pp. Describes various sets, uses, price list, lettering samples and photographs of interchangeable nibs which are available. John Henschel & Co, Inc, 105 E 29th St, NY, NY.

(A-110) **Photoelectric Components**–Bulletin, 4 pp. Describes models, styles, specifications, applications, and ordering procedure. Tri-Tronics Co, 2607 St Charles Rd, Bellwood, Ill.

(A-111) **Accelerometers**–Bulletin, 8 pp. Describes features, performance characteristics, mechanical and electrical specifications and applications. Gulton Industries, Inc, 212 Durham Ave, Metuchen, NJ.

(A-112) **Thermistors**–Bulletin, 12 pp. Specifications, applications, temperature charts and curves, static characteristics and ordering information. Gulton Industries, Inc, 212 Durham Ave, Metuchen, NJ.

(A-113) **Cartridge Heating Elements**–Catalog, 12 pp. Describes construction features of standard units and modifications. Gives wattage determination formulas and graphs. Hotwatt, Inc, 75 Maple St, Danvers, Mass.

(A-114) **Precision Potentiometers**–Catalog, 28 pp. Description and technical information on a line of single turn precision potentiometers from ½ in. to 5 in. in diameter. Dejur-Amsco Corp, Electronic Sales Div, 45-01 Northern Blvd, Long Island City 1, NY.

(A-115) **Laboratory Equipment**–Bulletin, 4 pp. Explains operation, construction features and application in glass shops or laboratories. Also describes pumps and other pneumatic equipment. Research Vacuum Supply Co, 6712 Clark St, Chicago 26, Ill.

(A-116 **Magnetic Tape Handler**–Brochure, 4 pp. Describes features, specifications and applications with applicable accessories such as amplifiers. Designed for digital data. Potter Instrument Co, Inc, Sunnyside Blvd, Plainview, NY.

(A-117) **Temperature Test Chamber**–Bulletin, 4 pp. Outlines construction and operation of portable environmental chamber suitable for bench testing small components within controlled temperature range of −65 C to +125 C. Magnetic Amplifiers, Inc, 632 Tinton Ave, NY 55, NY.

(A-118) **Electric Heating Elements**–Brochure, 4 pp. Graphite film and nichrome wire types of electric heating blankets sandwiched in neoprene, epoxy or silicone rubber for operation up to 500 F. Electrical Coatings Inc, 102 Rantoul St, Beverly, Mass.

(A-119) **Identification Materials**–Brochure, 12 pp. Description of printed pressure sensitive adhesive materials used for labels, nameplates or instructions. Topflight Corp, 160 E 9th Ave, York, Pa.

(A-120) **Identification Plates**–Brochure, 15 pp. Lists different types of products, facilities, photographs of the manufacturing process. Geo J Mayer Co, Inc, 546 E Market St, Indianapolis, Ind.

(A-121) **Potentiometers**–Catalog, 22 pp. Data sheets describing potentiometers: variable, wire wound, rotary, precision, single turn; 8, 9 and 10 digit; goniometers, with and without geared knob. Electro-Mec Laboratory, Inc, 47-51 33rd St, Long Island City 1, NY.

(A-122) **Vertical and Roll Filing Equipment**–Catalog, 12 pp. Describes space-saving way to file and protect plans, blueprints, negatives. Plan Hold Corp, 5204 Chakemco St, South Gate, Calif.

(A-123) **Aerosol Sprays**–Catalog, 16 pp. Gives description, functions, operation and advantages. Illustrates standard industrial products packaged in pressure spray cans. Crown Industrial Products Co, 713 Amsterdam St, Woodstock, Ill.

(A-124) **Abrasion Testing Sets**–Bulletin, 12 pp. Designed to evaluate the resistance of surfaces to rubbing abrasion. Shows types of wheels available for simulating actual wear. The wear action is continuous throughout a 360 degree rotation. Taber Instrument Corp, 111 Goundry St, North Tonawanda, NY.

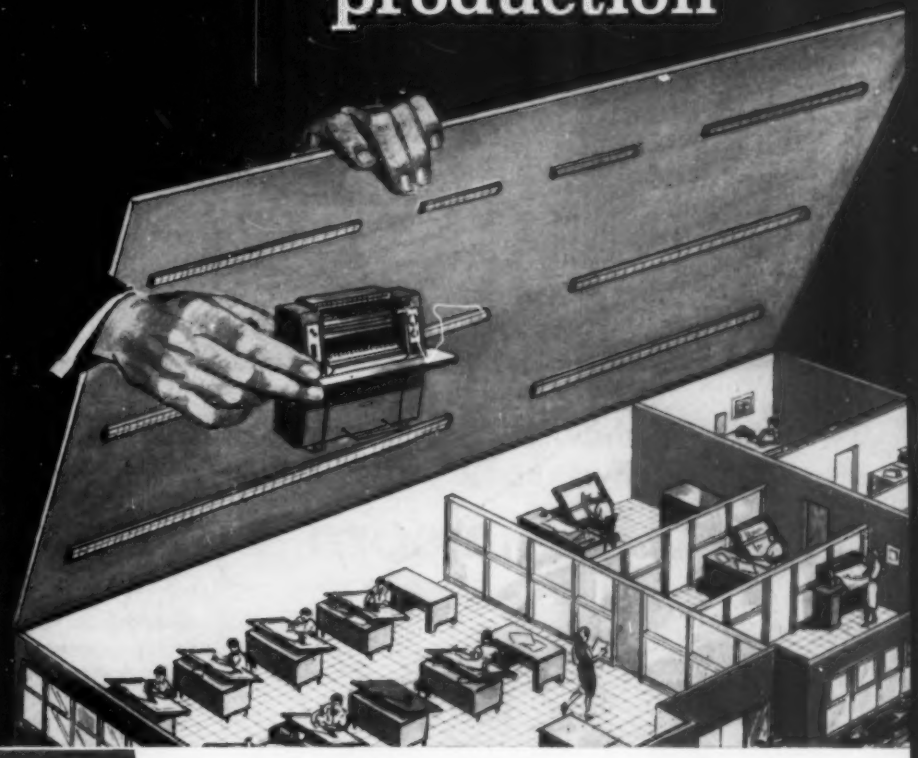
(A-125) **Radioisotope-excited Light Sources**–Bulletin, 4 pp. Describes units consisting of radiation-responsive phosphor crystals, enclosed in hermetically sealed transparent capsule and excited to luminescence by radioactive material or tritium gas. United States Radium Corp., PO Box 246, Morristown, NJ.

(A-126) **Drafting Aids**–Catalog, 32 pp. Includes description of pressure sensitive tapes for making layouts, plastic grid-sheets, pens and other equipment. Chart-Pak, Inc, 1 River Rd, Leeds, Mass.

(A-127) **Lineal-measuring System**–Brochure, 2 pp. Describes application of non-contact magnetic recording for measurement of lineal footage of rolled metals, quality controls, and others. Designers for Industry, Inc, 4241 Fulton Pkwy, Cleveland 9, Ohio.

(A-128) **Microfilm**–Brochure, 8 pp. Cites use of modern microfilm systems for duplicating, filing and safeguarding engineering drawings. Recordak Corp, A Subsidiary of Eastman Kodak Co, Wanamaker Pl, NY 3, NY.

how the Bruning Man raises the "ceiling" on drafting room production



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In this era of fast, intense, and ever-changing engineering progress; drafting departments are being called on for faster, more accurate work. Costly expansion need not be the only answer. Read on the following pages how the Bruning Man's reasonably priced modernization program will more than pay for itself in greater production and lower costs.

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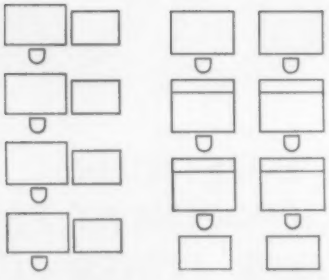

Conventional Arrangement

Auto-Shift Arrangement

1. Hamilton Auto-Shift Tables. You can put six modern Auto-Shift units where you now have four boards with separate reference desks. Unique design of Auto-Shift lets draftsman work on any part of the board, reach reference table and drawers without leaving his seat. Your draftsmen work faster and better with far less fatigue.

2. Hamilton "L" Contour Tables. The unique "L" shape of this combination board and desk unit provides new reference convenience, new personalized working space, new smartness of surroundings for modern draftsmen and engineers. They work faster, better, and with more pride in their work and surroundings.

3. Hamilton UnitSystem Files. You file drawings and records in units especially designed for them by size and frequency of use. Drawings are faster to file and find. UnitSystem's interlocking feature lets you combine exactly the units you need in higher stacks to save space and to expand filing efficiently and economically.

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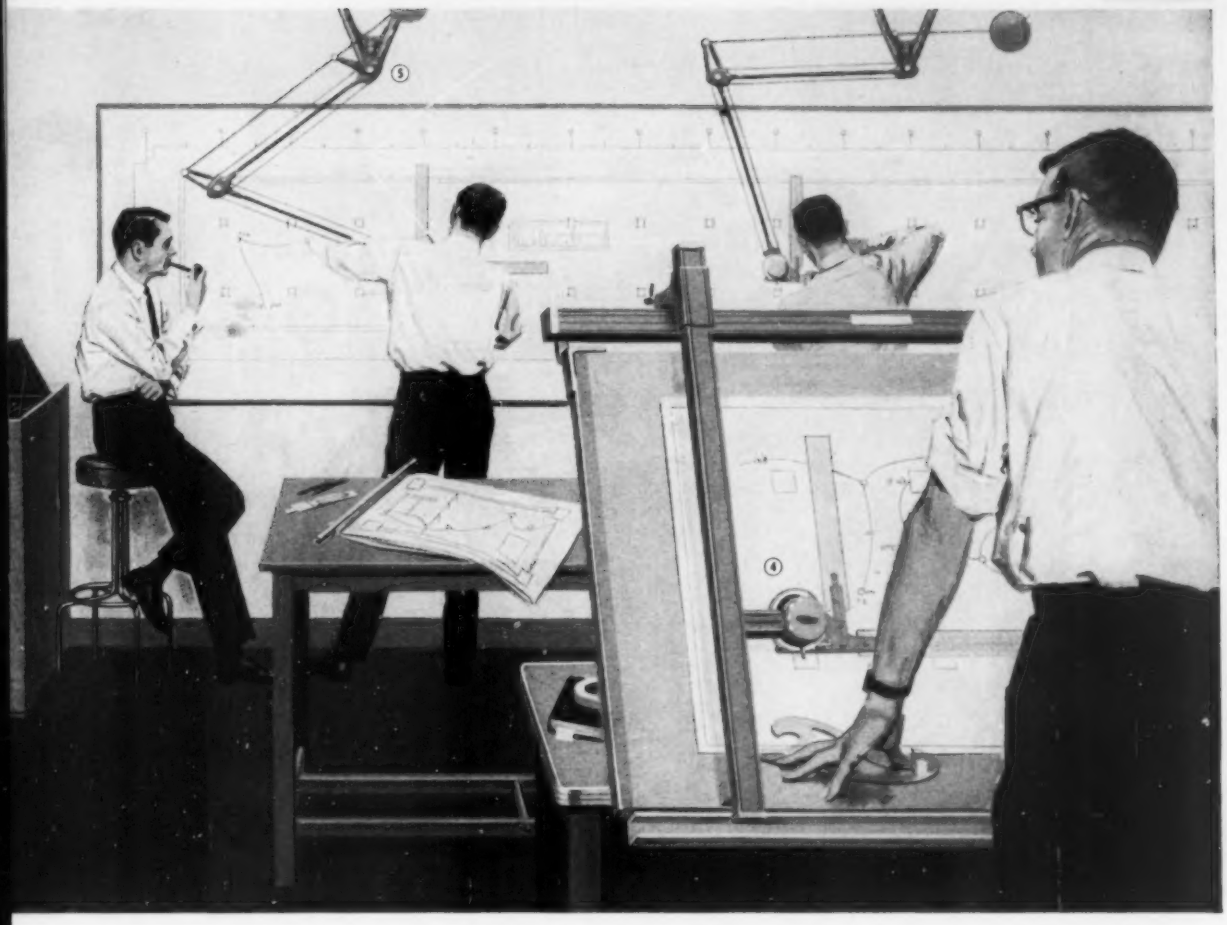

modernize to speed drafting up to 40% with

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Over conventional equipment, modern Bruning drafters speed drafting up to 40% on most jobs . . . up to 50% on some structural drawings. They are far faster and easier to operate than any other drafting machine on the market.

4. All-New Neoglide Drafters. A complete departure from conventional drafting machine design, Bruning's new Neoglide drafters give the draftsman complete maneuverability on any board **at any angle.** Reinforced U-beam construction offers amazing rigidity, strength, and accuracy. Yet resistance-free movement of the counterweight and vertical beam provide free-and-easy "floating" action. No cables or belts to break, stretch, or sag. Touch-control protractor head gives automatic, pin-point angle selection at a touch of the control button.

5. Bruning Track Drafters. Here is the modern, space-saving way to turn out large drawings, faster and more accurately. Unsurpassed anywhere, Bruning track drafters offer automatic indexing, double veniers, and fast scale changes. Models available to provide vertical coverage up to 84" and unlimited horizontal coverage.

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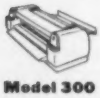
There's a Modern Bruning Copyflex Machine to Meet Every Need and Budget.

Model 675

Model 35

Model 250



Model 300

Copytron Microfilm Printer

Model 42

1. New Copyflex 675. Years ahead of any reproduction machine, Bruning's Model 675 offers a host of new time-and-work-saving advantages. These include a four-way tracing tray that adjusts to stack or permit fast removal of tracings . . . a feed band system that eliminates curling of tracings . . . enclosed easy-to-load feed rods for roll stock . . . unique system of vacuum ports in the feedboard that hold large sheets and roll stock in position . . . a split-shade lamp control that enables simultaneous insertion of different materials . . . and an electrically controlled push-button machine height adjustment. It offers a mechanical speed of up to 75 f. p. m. and a fast-printing 7,500 watt lamp variable to 5,000 watts, takes sheets and roll stock up to 42" wide.

2. Modern Copyflex 300. This unique, low-cost table top model offers a full 30-inch printing width, gives you professional prints in seconds. By supplementing your main reproduction center with strategically located 300's, you add new dimensions in convenience and economy to your department.

Copyflex machines are odorless, require no venting or plumbing. 8½ x 11" prints cost 1¼¢ each for materials.

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modernize to slash time of re-working drawings up to 90% with

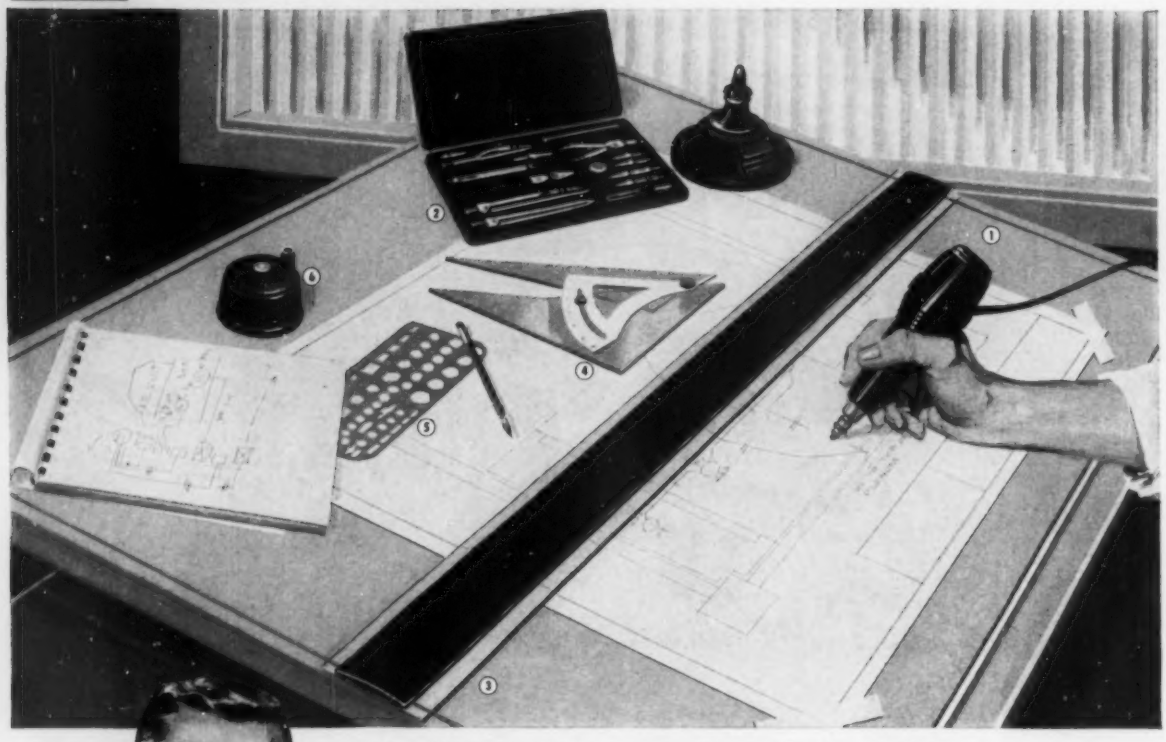
intermediates

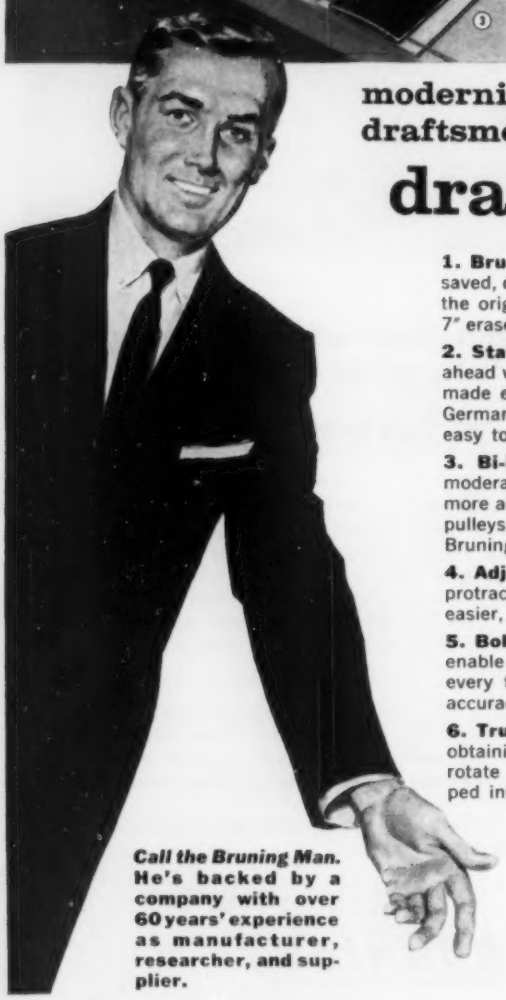
3. For design changes or re-working old drawings, modern Bruning intermediates can save up to 90% of the tracing usually required. The draftsman has a Copyflex intermediate (reproducible print) made of the original drawing. Unwanted portions can either be masked out in the printing operation or eradicated on the intermediate itself. New lines then can be added to the intermediate without the tedious, time-taking work of tracing those sections which do not require alteration.

Bruning versatile intermediates are also widely used to speed and simplify print distribution. Sent to distant points, intermediates can be used again and again to make needed prints or to incorporate changes without waiting for new prints from headquarters.

Bruning's complete line of intermediates include paper, matte film, clear film, and cloth.

BRUNING





modernize to speed and simplify draftsmen's work with

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2. Stainless-Supreme Drawing Instruments. You'll be time and money ahead with higher precision, durability, and beauty offered only by instruments made entirely of non-tarnishing stainless steel. 5 times harder than brass or German silver. Specially hardened, swivel-type ruling pen points are fast and easy to clean.

3. Bi-Liner Parallel Straightedge. Over conventional T-squares, these moderately priced straightedges more than pay the price difference in faster, more accurate drafting. Features include: warp-proof blade, ball bearing blade pulleys, full length duraluminum tunnel, board-top mounting attachments. Bruning's complete line includes special model with retractile rollers.

4. Adjustable Triangle. This modern precision tool combines the functions of protractor and universal triangle to enable draftsmen to draw all angles faster, easier, and more accurately. Will not discolor or become brittle. Range of sizes.

5. Bolts and Nuts Template. Bruning's wide variety of modern templates enable faster, neater, more uniform execution of symbols and shapes for every type of drawing. Precision-cut from wear-resistant plastics to assure accuracy and durability.

6. Tru-Point Lead Pointer. Here is the fast, convenient, pleasant way of obtaining clean, ideal draftsman's points. Only one hand need be used to rotate pencil and pointer top around stationary base. Graphite dust is trapped inside. Abrasive liners are replaceable.

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GENERAL ENGINEERING

catalogs and bulletins.....continued

(A-129) Vibration Meters—Bulletin, 3 pp. Describes miniaturized vibration pickup, performance features; used for vibration measurement and analysis. MB Mfg Co, PO Box 1825, New Haven 8, Conn.

(A-130) Transparent Plastic Boxes—Brochure, 4 pp. Describes varied uses for stock sizes and compartment arrangements of transparent plastic boxes for kit, spare parts and assortment packaging, as well as in plant storage of small parts. The Vlchek Tool Co, Plastics Div, 3001 E 87th St, Cleveland 4, Ohio.

(A-131) Testing Equipment—Brochure, 4 pp. Describes environmental testing that can be performed under engineering supervision. Lists some functional test equipment available. Parameters, Inc, 195 Herricks Rd, New Hyde Pk, NY.

(A-132) Laminated Panels—Bulletin, 16 pp. Covers various combinations of core and face materials, edge treatment, engineering data, and applications. Met-L-Wood Corp, 6755 W 65th St, Chicago 38, Ill.

(A-133) Tape Recorders—Brochure, 6 pp. Describes mechanical and electrical features, specifications and direct factory prices as well as accessories. Amplifier Corp of America, 398 Broadway, NY 13, NY.

(A-134) Camera Lens Turret—Brochure, 4 pp. Describes advantages, mounting of motors and shafts. Also gives price and maintenance information. Visual Electronics Corp, 356 W 40th St, NY 18, NY.

(A-135) Testing Equipment—Bulletin, 5 pp. Describes several test equipment consoles providing automatic systems for determining thermal conductivity of insulating materials. Parameters, Inc, 195 Herricks Rd, New Hyde Park, NY.

(A-136) Modular Enclosure Systems—Catalog, 112 pp. Contains specifications, diagrams, engineering drawings and photographs of frames and component parts of various metal cabinets. Elgin Metalformers Corp, 630 Congdon Ave, Elgin, Ill.

(A-137) Dynamic Measuring and Recording Instruments—Catalog, 16 pp. Provides description of methods, operational principles, components and specifications of multichannel oscillographs for dynamic testing. Electro-Mechanical Instrument Div, Consolidated Electrodynamics Corp, 300 N Sierra Madre Villa, Pasadena, Calif.

(A-138) Executive Training Program—Catalog, 48 pp. Explains format of program designed to develop executive talents. Alexander Hamilton Institute 71 W 23rd St, NY, NY.

(A-139) Torque Measuring Device—Bulletin, 23 pp. Includes formulas, graphs, schematic diagrams, circuit drawings and applications for small torque motors and precision gyroscopes with threshold of 0.05 dyne-cm. Describes principle of operation, mechanical and electrical features. Eder Engineering Co, Inc, 1568 S First St, Milwaukee 4, Wisc.

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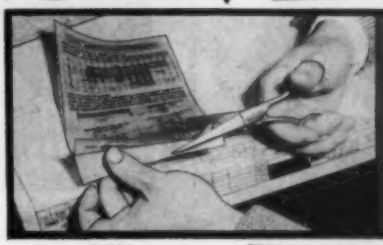

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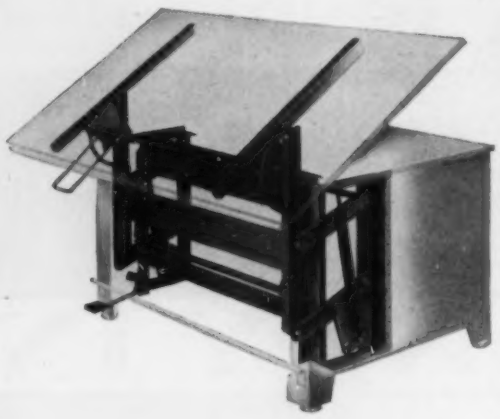

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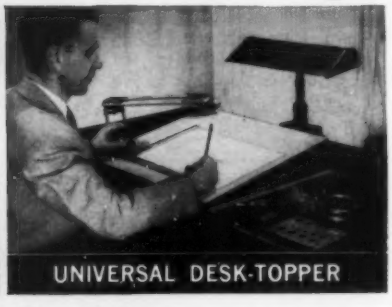

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GENERAL ENGINEERING

catalogs and bulletins.....continued

(A-140) Physical Testing Equipment—Catalog, 80 pp. Evaluates textiles, rubber, plastics, wire, paper, leather, and others for tensile strength, test-tube aging, adhesion, tear, compression, burst, internal bond, flexing, rubber-to-metal, hysteresis. Scott Testers, Inc, 101 Blackstone St, Providence, RI.

(A-141) Contact Meter-relays—Catalog, 40 pp. Describes design principle and typical application circuits, with ordering information on models and sensitivities; also mentions indicating panel meters and package controls built around meter-relays. Assembly Products, Inc, 75 Wilson Mills Road, Chesterland, Ohio.

(A-142) Digital Instrument—Brochure, 8 pp. Description and specifications of electronic counters and timers for measurement, calibration, timing and control purposes. Erie Resistor Corp, 644 W 12th St, Erie 6, Pa.

(A-143) Electron Accelerators and Radiation Processing—Brochure, 31 pp. Covers types of radiation and sources; engineering and economic factors in electron beam processing; accelerator installation and applications. High Voltage Engineering Corp, S Bedford St, Burlington, Mass.

(A-144) Test Equipment—Catalog, 8 pp. Gives voltage and resistance ranges, accuracies, accessories and prices for vacuum tube volt-ohmmeters, microtestors, television and radio test equipment. Simpson Electric Co, 5200 W Kinzie, Chicago, Ill.

(A-145) Ultra-violet Lamp—Catalog, 2 pp. Gives data for specialized uses of small size ultra-violet lamps in optical instrument and laboratory applications. Ultra-Violet Products, Inc, 5114 Walnut Grove Ave, San Gabriel, Calif.

(A-146) Thermostats—Brochure, 8 pp. Lists specifications, gives engineering information, photographs of several models and illustrations of actual operation in plants. The Franklin Dales Co, 180-184 E Mill St, Akron 8, Ohio.

(A-147) Environmental Chambers—Brochure, 28 pp. Presents line of standard and custom built environmental chambers. Technical data on specific heats, metal shrinkage, atmosphere and high altitude charts, temperature and humidity tables, and refrigeration schematics. Webber Engineering Corp, PO Box 217, Indianapolis 6, Ind.

(A-148) Tape Punch—Brochure, 4 pp. Describes construction and gives specifications of standard unit along with other technical information on motorized paper tape punch. Precision Specialties, Inc, 1342 E 58th St, Kansas City, Mo.

(A-149) Ultra-miniature Indicator Lights—Brochure, 8 pp. Discusses basic styles, construction materials, specifications, plug-in lamp cartridges and assemblies, schematics. Used in data processing equipment, computers, and others. Dialight Corp, 60 Stewart Ave, Brooklyn 37, NY.

(A-150) Analog Converters—Brochure, 8 pp. Describes translation of various binary codes into decimal equivalents; and gives operational characteristics, dimensions, photographs and codes for each type. Kearfott Co, Inc, 1500 Main Ave, Clifton, NJ.

(A-151) Electronic Test Equipment—Catalog, 4 pp. Specifications on wide band oscilloscope, pulse generator, standard calibrator, ac-dc dynamometer instruments, general purpose microtesters, volt-ohm milliometers, VTVM's. Simpson Electric Co, 5200 W Kinzie, Chicago, Ill.

(A-152) Counters—Catalog, 57 pp. Describes mechanical and electric counters, digital readout instruments, programmers, contactors and photo controls. Gives operating characteristics, installation photographs and dimensional drawings. Durant Mfg Co, 1938 N Buffum St, Milwaukee, Wisc.

(A-153) Flowmeters—Bulletin, p 66. Description of meter construction for indicating flow rate of industrial gases. Contains capacity tables for common gases, dimensions and pipe sizes. Waukee Engineering Co, Inc, 5138 N 35th St, Milwaukee 9, Wisc.

(A-154) Altitude Simulation Chambers—Bulletin, 2 pp. Complete with instrumentation, high-capacity pumping systems and feed-throughs. Sizes from laboratory to walk-in chambers, capable of altitudes to above 100 miles. General Vacuum Corp, 400 Border St, East Boston 28, Mass.

(A-155) Component System for Instrument Cabinets—Catalog, 20 pp. Cabinet component system of prefabricated dural diecast corners, extruded sections and parts assembles into fully radiused cabinets to any dimensions with no special tools, dies or jigs. British Industries Corp, 80 Shore Rd, Port Washington, NY.

(A-156) Pressure Gages and Dial Thermometers—Catalog, 12 pp. Illustrates and gives design features, materials and accuracy ranges of high pressure gages and dial thermometers for military and commercial use. Rochester Mfg Co, Inc, 100 Rockwood St, Rochester, NY.

(A-157) Rotary Potentiometer—Brochure, 6 pp. Describes series of precision potentiometers hermetically sealed for high temperature operation. An homogenous metallic film is the resistance element. Includes test data, mechanical and electrical specifications. Technology Instrument Corp, 531 Main Street, Acton, Mass.

(A-158) Hour Meters and Accessories—Catalog, 12 pp. Shows running time meters for both dc and ac use on power equipment to record total running time. John W Hobbs Corp, Div Stewart-Warner Corp, PO Box 358, Springfield, Ill.

(A-159) Industrial Weighing Equipment—Catalog, 85 pp. Describes manual, semi-automatic, and fully automatic mechanical and electronic weighing equipment with specifications. The Exact Weight Scale Co, 540 E Town St, Columbus 15, Ohio.

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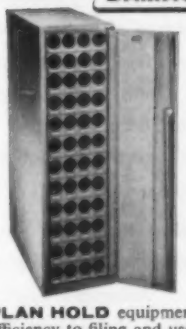

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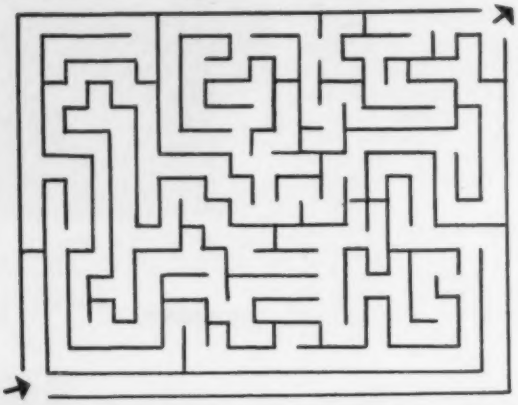

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catalogs and bulletins.....continued

(A-160) Tape Dispensers—Brochure, 2 pp. Used with pressure sensitive tapes: nylon, rayon, paper strapping, masking, drafting, single and double coated liner wound tapes. Trade Aid Supplies Co, 1316 E 24th St, Minneapolis, Minn.

(A-161) Temperature Controls—Catalog, 56 pp. Describes construction and applications of diversified types of temperature controls. Gives specifications and ordering information for thermostats, hot water, steam and gas burner controls. White-Rodgers Co, 1209 Cass Ave, St Louis 6, Mo.

(A-162) Industrial Timers and Measuring Instruments—Bulletin, 10 pp. States electrical ratings and capacities of various reset, cycle and dial timers. Gives mounting data and basic circuit arrangements. Automatic Timing & Controls, Inc, King of Prussia, Pa.

(A-163) Coincident Current Magnetic Memories—Bulletin, 8 pp. Covers the basic operation, squareness ratio and hysteresis loop materials. Includes drawings and technical bibliography. General Ceramics Corp, Crows Mill Rd, Keasbey, NJ.

(A-164) Oscillographic Recording Systems—Catalog, 16 pp. Explanation of modular construction, suggested applications, performance data and technical specifications. Sanborn Co, 175 Wyman St, Rte 128, Waltham 54, Mass.

(A-165) Industrial Markers—Catalog, 6 pp. Illustrates and describes line of crayons, chalks and pencils for marking purposes. The Joseph Dixon Crucible Co, 167 Wayne St, Jersey City, NJ.

(A-166) Industrial and Domestic Cleaning Brushes—Catalog, 119 pp. Gives sizes, uses, prices, and construction materials of brushes for plant and home use. Flour City Brush Co, 1501 Fourth Ave S, Minneapolis 4, Minn.

(A-167) Custom Consoles and Cabinets—Brochure, 8 pp. Photographs and dimension drawings of typical cabinet racks and consoles for teletypwriters, instrumentation, controls, and others. Northeastern Engineering, Inc, 25 S Bedford St, Manchester, NH.

(A-168) Retractile Cords—Catalog, 16 pp. Application section with description and photographs. Includes data on communication, power and heater cords. Instructions given for ordering special types. Koiled Kords Div, Whitney Blake Co, 104 Pershing St, Hamden, Con.

(A-169) Radiation Detection Equipment—Brochure, 4 pp. Sizes, operating ranges and applications are given for radiation survey meters, dosimeter chargers and combinations. Tung-Sol Electric Inc, 95 Eighth Ave, Newark 4, NJ.

(A-170) Potentiometers—Brochure, 11 pp. Outline drawings, general specifications and temperature ranges on various models for trimmer application. Carter Mfg Corp, 23 Washington St, Hudson, Mass.

SECTION B

METALS AND ALLOYS

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DESIGN ABSTRACTS

MAGNESIUM— A MISSILE METAL

At least 20 different missile systems are now making use of magnesium's light weight in both missile and ground equipment structures.

Comparison Curves

Several major reasons for the magnesium-thorium alloys' popularity with missile designers are illustrated in graphs. One of these reasons is comparative resistance to buckling at temperatures up to 700 F. Curves compare magnesium sheet, at an 18% weight saving, with aluminum alloy sheet and show that magnesium has slightly greater buckling resistance at this lower weight. Other curves compare the two materials at equal weight. In this case, the magnesium structure would be approximately 60% stronger than the aluminum structure.

Structural stiffness also is a factor considered by designers, particularly in relation to the problems of aeroelasticity and flutter. In another graph, curves compare the high-temperature magnesium sheet alloys, at an 18% weight saving, with aluminum alloy sheet. For equal weight, magnesium is over twice as stiff.

The very high specific heat of magnesium alloys results in excellent heat-sink capacity. Graph illustrates how, in a hypothetical transient heating environment, magnesium (on an equal-weight basis with three other missile metals) will have a considerably-lower skin temperature. This difference in temperature between magnesium and steel or titanium can amount to as much as 200 to 300 F.

"Why Magnesium Is a Missile Metal," The Dow Chemical Co; "Magnesium", May '59, 1950 W Fort St, Detroit 16.

*

Toolsteel for Aircraft

Used for many years in special dies, the 5% chromium toolsteels (H-11) are being accepted as a structural material in supersonic aircraft and missiles. Heat treatable to 280,000 to 300,000 psi tensile strength, the steel resists softening up to 925 F. Impact and fatigue strengths are also adequate.

"Hot Work Toolsteel for Aircraft," P E Ruff, North American Aviation Inc; Metal Progress, March '59, 7301 Euclid Ave, Cleveland 3.

*

Aluminum Plus Plastic

A new structural material consisting of expanded polystyrene foam, sandwiched between two sheets of aluminum, bids fair to revolutionize the design and construction of many other products. The best characteristics of aluminum and foam plastic are combined.

"Aluminum Plus Foamed Plastic," Modern Metals, Feb '59, 435 N Michigan Ave, Chicago 11.

*

Dry Adhesive Wear

Sliding-motion experiments on various steels and brass under unlubricated conditions are discussed in terms of simple wear theory advanced by Archard.

"An Investigation of Dry Adhesive Wear," R P Steijn, E I duPont de Nemours & Co, Paper 58-LUB-8, ASME, 29 W 39th St, New York 18.

*

Cast Iron Ductility

Where is the search for ductility leading? Gases in steel have been closely studied, but even today there is much doubt concerning the phenomena encountered. Still more is this so with cast iron and its gas content.

Gas content

The technique of vacuum-fusion analysis has proved highly important in evaluating the gas content of both gas and steel, though it has its critics. However, it has been established that oxygen in cast iron is mainly in solution in the iron, and a characteristic grey iron contains from 0.001% to 0.025% by weight (Brit. Cast Iron Res. Assn.). Cast irons that have failed in service often show an abnormally high oxygen content, but if this content exceeds 0.02% it may not be the result of excessive oxygen content but of defective testpieces or those embodying occluded slags of oxides, as has been frequently demonstrated.

Evaluating notch ductility

One of the most essential properties in modern engineering materials is ductility, and this applies particularly to those irons known as nodular irons. Sometimes, when impact tests of these irons are carried out, using a notched testpiece, a degree of brittleness is found that is sufficient to cause service failure. Consequently, research has been devoted to evaluation of the notch ductility properties of these irons as a means of increasing the knowledge gained from study of the tensile properties.

"Cast Iron Research and Development," Mechanical World, Jan '59, 31 King Street West, Manchester 3, England.

*

Sponge Iron

Sponge iron is a metallic product reduced from iron ore at such a low temperature that melting of the iron or the gangue constituents has not taken place.

Sponge iron is, therefore, more or less porous, which accounts for its name, and contains most of the impurities present in the iron ore from which it is made. On the other hand, it cannot contain impurities that are normally introduced to the iron from the reducing agent or from additives to other processes where the iron becomes molten. Contrary to scrap, sponge iron is virtually free from al-

loying elements and from so-called tramp elements such as copper, tin, nickel, etc.

Direct reduction of iron ore has been practiced in Sweden for over 40 years and the product, sponge iron, has in increasing amounts been utilized as a raw material for quality steel production primarily in acid open hearth and induction furnaces and basic electric arc furnaces.

"Sponge Iron Defined," P. Ulf Gummeson, Brochure, Hoeganaes Sponge Iron Corp, Riverton, New Jersey.

*

Effect of Sleeve Material on Fatigue Strength of Shafts

Pronounced differences in fatigue strength of shafts carrying pressed-on sleeve components have been ascribed mainly to fretting corrosion previously. For example, hardened-steel on carbon-steel shafts have reduced endurance limit up to 47% of the base shaft. A series of tests wherein split sleeves were pressed on 0.45% carbon-steel shafts by a collet-type fitting indicated a reduction of about 50% of base shaft regardless of sleeve material or hardness. This reduction does not occur in rolled shafts, nor in those ground after rolling.

"Effect of the Material of an Enveloping Sleeve on Fatigue Strength of Axles and Shafts," Kudyavtsev and Savvino, Vestnik Machinostroyenya, Vol. 36, No. 7, Moscow, USSR.

*

Cemented Carbides

Kentanium, a trade name for a series of cemented carbide compositions based on titanium carbide, was developed primarily for use at temperatures and stress conditions under which no alloys or ceramic materials have been satisfactory. These materials can be subjected continuously to temperatures up to 2200 F. under operating conditions, and can be used at temperatures up to 5000 F. for short periods of operation. A low specific gravity, plus other physical properties such as high Young's Modulus of elasticity, excellent compressive and tensile strength combine to offer advantages for many applications over a wide range of temperatures, including sub-zero conditions.

"Kentanium," Brochure, Kennametal Inc., Latrobe, Pa.

*

Ductile Vanadium

Sources of ores, extraction, reduction and refining methods, fabrication, availability, properties are discussed.

"Ductile Vanadium—A New Engineering Material," T W Merrill, Vanadium Corp of America, Manufacturing Chemists Assn, 1625 Eye St, NW, Washington 6, DC.

*

Conductivity of Aluminum Honeycomb

Results of thermal-conductivity tests on a series of aluminum honeycomb panels. Thermal resistances are correlated in terms of honeycomb-cell geometry and type of adhesive bonding between core and outer skin.

"The Thermal Conductivity of Aluminum Honeycomb Material Near Room Temperature," R V Dunkle, J T Geir, University of California, and J T Bevans, Shell Development Corp; ASME paper 58-SA-1, ASME, 29 W 39th St, New York 18.

*

Aluminum Castings

Permanent-mold aluminum castings are produced from a variety of aluminum alloys. They are made by pouring molten alloy into a metal mold—either book shaped or in two parts.

The inside of the mold is coated with a "wash" which is a slurry of clay, graphite, whiting, or other refractory earth in a sodium-silicate binder. The wash is sprayed while the mold is hot and is allowed to cake. The insulating coat affects the way the metal pours and solidifies, protects the surface.

As a process, and also according to the properties of the casting, permanent-mold casting stands between sand casting and pressure die casting. Several tables compare costs, production, and properties. Design hits are also included.

"Permanent Mold Aluminum Castings," P C Noy, Canadian General Electric Co; American Machinist, May 18, 1959, 330 W 42nd St, New York 36.

*

Crack Initiation in Aluminum Sheet

Low cycle–high stress fatigue tests in fluctuating tension on transverse and longitudinal specimens of 1100-H-18 aluminum determined at several stress levels the number of cycles required to initiate crack of arbitrary length at root of mild, semicircular notch and then to propagate crack to failure. Fatigue crack growth is shown to consist of short bursts of growth followed by periods of no measurable growth. Cracks in transverse specimens propagated faster.

"Anisotropy of Crack Initiation and Propagation in Cold-rolled Aluminum Sheet," Lipsitt, Forbes and Baird, Wright Air Development Center. Presented at 62nd Annual Meeting of ASTM, June 21-26, 1916 Race St, Philadelphia 3.

*

Rust Preventives

Metallic and nonmetallic coatings, petroleum-base materials, volatile inhibitors and evaluation procedures for all are discussed.

"Rust Preventives," E J Colerick, Shell Oil Co, Lubrication Engineering, Aug 1958, 84 E Randolph St, Chicago 1.

Design for CORROSION RESISTANCE

Corrosion resistance is an integral part of a design. Material selection is not the final answer, but how easy is the part to clean, is the fluid flow laminar, are parts stressed close to the yield limit, and are there crevices that might promote attack.

NORMAN D. GROVES
Corrosion Engineer
The Carpenter Steel Company

Major classifications of corrosive attack are: general, intergranular, concentration cell, galvanic pitting, stress corrosion cracking, corrosion erosion, and dezincification. Often, fretting and crevice corrosion can be added to the other major types of corrosion.

Material selection can be a cause of corrosion, and where failure is due to general corrosive attack this is true. But, configuration can help resist corrosive attack; as well as the method of assembly and insulation, respectively, are controlling factors to intergranular and galvanic attack. In fretting corrosion, relative motion, bearing pressure and lubrication are major considerations.

Hence, shape, method of assembly, relative motion, bearing pressures, and lubrication are all factors that directly influence corrosion rates in the majority of types of corrosion; corrosion resistance is, therefore, a design problem. Table I shows types of corrosion that are design responsibilities and should be avoided.

BASIC DESIGN PRACTICES

There are some basic practices that should be followed to improve resistance to all types of corrosive attack.

Make cleaning easy. Generally, the corrosion resisting properties of stainless steel are due to a very thin film of oxide that completely covers the surface and prevents oxidation. Attack occurs when this film is broken or contaminated by dirt or scale adhering to the surface. A freshly cleaned, machined, polished, or pickled part will acquire this film. Frequent cleaning preserves the protecting coating.

Sharp corners permit dirt to accumulate as they are difficult to clean; a rounded or filleted edge will simplify cleaning. Fig. 1 shows some good and bad configurations.

Finishes should be consistent with the accessibility of the equipment for cleaning. For example, pipe interiors that can be cleaned only by flushing, require a more highly polished surface than an exposed readily cleaned surface subjected to the same fluid.

Designed for replacement. It may cost less to design the part for easy replacement when chemical attack occurs. The heat exchanger section of a system, for example, should be replaceable. The metal may be sufficiently corrosion resistant for the rest of the process, but the elevated temperatures of the heat exchanger will increase the corrosive attack. Any section of a system that may be subjected to higher corrosion rates than normal throughout the rest of the system should be replaceable.

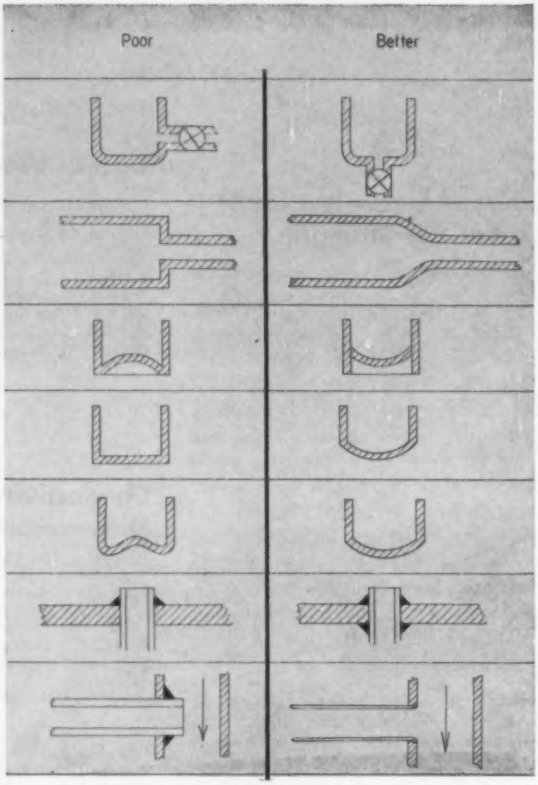
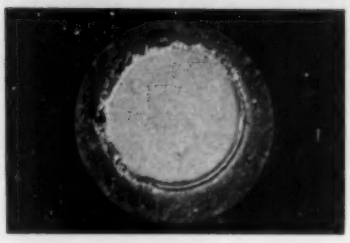
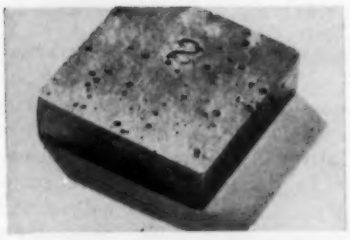
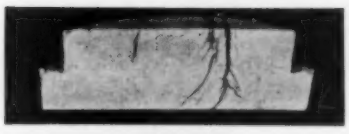
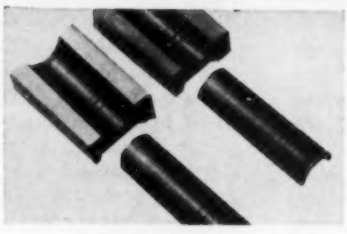


Fig. 1—Good and bad configurations of sharp corners, constrictions, projections and pockets.

Use fluid present. When corrosive fluid is added to a vat, Fig. 2, in a more highly concentrated form than is present, introduce the concentrate into the center of the vat. In this way, the fluid will dilute the concentrate before contacting the sides of the vat.

Streamline design. This can prevent corrosive attack from many angles. It makes equipment easy to clean, and laminar flow is less apt to break down the protective oxide film as turbulent flow. Also, avoid abrupt constrictions

TABLE I–TYPES OF CORROSION

INTERGRANULAR		Attack along grain boundaries generally found in welded areas.
CONCENTRATION CELL		Localized attack brought on by stagnation or eddying of the process fluid causing an area of increased concentration.
GALVANIC		General attack when two dissimilar metals are in contact and immersed in a fluid capable of carrying an electric current.
PITTING		Localized attack exhibited by corroding deeply in individual spots.
STRESS CORROSION CRACKING		Transgranular cracks resulting from combined effects of stress and corrosion.
FRETTING		Localized attack resulting from corrosion and oscillatory motion of parts under load—may resemble mechanical wear.
EROSION		Combined effect of corrosion and impingement of fluid or particles.

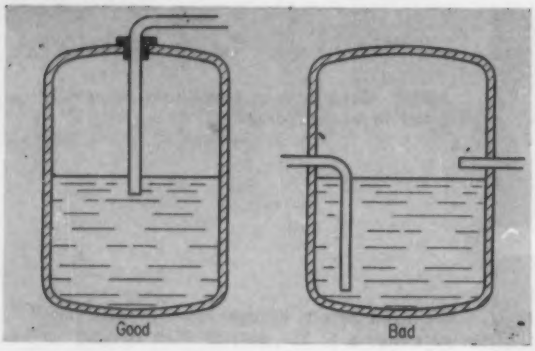


Fig. 2—Introduce concentrated liquid into center of vat so liquid can dilute before reaching edges. Another way to prevent galvanic attack is by insulating the vat from the piping.

in fluid lines such as weld joints with backup rings, underside valves, butt joints and others. Sediment can collect and form natural cracks and crevices exposing the edge of the material to the corrodent.

CORROSION CURES

When the cause for a failure is determined, some cures lie within the realm of the design; others do not. Some of the corrective measures are applicable to several types of failure; for example, poor welding which can cause crevice corrosion, constrictions for sediment buildup, and intergranular corrosion.

Intergranular corrosion. This is usually a problem of material selection or proper heat treatment. The only design correction might be another method of fastening. Intergranular corrosion due to welding is often overcome by specifying the proper grade of steel such as low carbon or a stabilized grade.

Concentration cell. Low concentration or a temperature differential—such as stratified layers of fluids or wherever stagnation or eddying occurs—will cause this corrosive attack. One of the most common types is crevice corrosion which occurs wherever the fluid flow is impaired.

To have crevice corrosion, the corrodent must become concentrated and can be caused by a thermal gradient or normal diffusion. No mechanical joint is tight enough not to be a crevice.

One common area of crevice corrosion is at a welded pipe joint. Fig. 3 shows several good joints that reduce the hazard of crevices.

Galvanic corrosion. This is a material selection problem as all one type of material would prevent it. However, different alloys often must be used to increase corrosion resistance according to the intensity of the attack. To have galvanic corrosion, there must be two circuits—one liquid and one metal. Destroy either of these circuits and galvanic corrosion cannot exist. Whenever possible use similar metals or insulated dissimilar metals.

Pitting corrosion. Experience indicates that pit-type corrosion occurs when the protective oxide coating is removed by scratching, denting, scoring or similar means. Also, halogen ions and some other reducing agents can prevent reformation of the protective oxide.

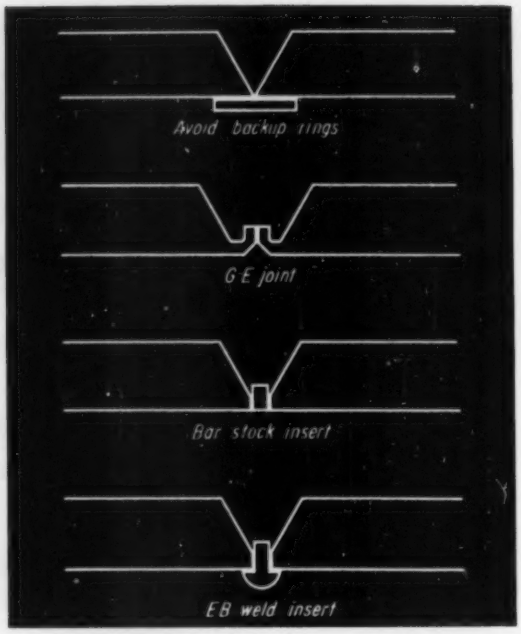


Fig. 3—Care should be taken in the type of weld joint used in process equipment. Backup rings should be avoided. Shown are several acceptable joints.

It is difficult to design against scratches, denting and similar damage, but if the parts are easy and accessible to cleaning, the oxide coating can be restored by solutions designed for this purpose.

A prevalent area for pitting corrosion attack is under sediment. Fluid can be taken from a tank by siphoning or draining. Siphoning allows sediment to form at the bottom of the tank to promote pitting. A superior design draws the fluid from the bottom of the tank.

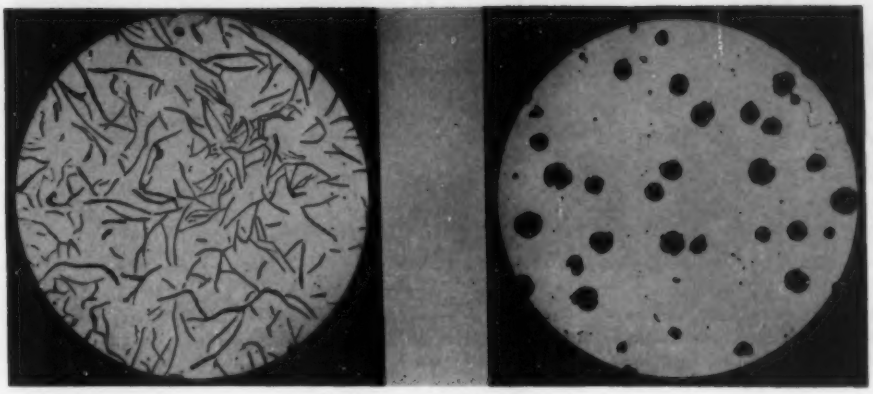
Stress corrosion cracking. This corrosive attack results from specific combinations of stresses and corrodents, and only when the material is in tension. Chlorides or chloride bearing solutions are the corrodents most conducive to stress corrosion cracking.

Residual stresses are the most prevalent in causing this type of failure. Fabrication and heat treatment control residual stresses. Proper annealing should be specified. Avoid bending, rolling or cold working of unannealed parts to be used in a chloride bearing atmosphere.

Fretting corrosion. This is a design problem and can be alleviated by the following steps.

1. Distribute the load over a wide area. In a bearing this is done by changing the radius of contact.
2. Increase material strength. Fretting is more prominent in the softer materials.
3. Increase pressure between parts to decrease slippage.
4. Roughen mating surfaces to avoid slippage.
5. Lubricate to place a film between mating surfaces.

Erosion corrosion. Design for laminar flow. This means using gradual radius bends, oversize valves, tube reducers for expanding and contracting flow lines, and long radius bends and elbows for liquids containing solids.



From: INCO

Iron differences . . . are visible in the left 250X unetched specimens. Typical gray iron with free carbon in flake graphite form is weakened by graphite interrupting the metallic continuity. Iron with spheroidal graphite permits a continuous matrix and reduces the concentration of stresses caused by flake graphite in the iron.

DUCTILE IRON in the Machine Tool Industry

Properties of prime interest to machine tool industry as well as examples of parts and reasons for use.

ROBERT M. BRONSON
Development & Research Division
The International Nickel Company

Ductile iron develops strength properties equal, in general, to those of carbon steel while at the same time possessing the processing advantages of gray cast iron, such as superior castability and machinability plus wear resistance vibration damping capacity, and good resistance to elevated temperatures. Extensive use is being made of the material by the machine tool industry in parts where it has offered advantages over malleable iron, cast iron, high strength gray iron and frequently wrought steel.

Ductile irons are a series of irons which possess appreciable ductility and toughness as the result of a modification of the graphite form. This is accomplished by the addition of small amounts of magnesium to the molten iron. The retention of magnesium causes the graphite to crystallize in a spheroidal form, rather than with random flakes which are characteristic of gray iron.

Graphite is weak, and when present in flake form interrupts the continuity of the strong metallic matrix, thus weakening the iron. The graphite flakes also present a multiplicity of metallurgical notches which act as stress concentrators and, therefore, have an embrittling effect. Graphite in spheroidal form permits a continuous matrix and reduces the concentration of stresses. The structural arrangement allows the steel-like matrix to develop its inherent strength and toughness. The chemical composition of ductile iron is similar to that of gray iron and Table I shows the composition limits of most of the castings produced.

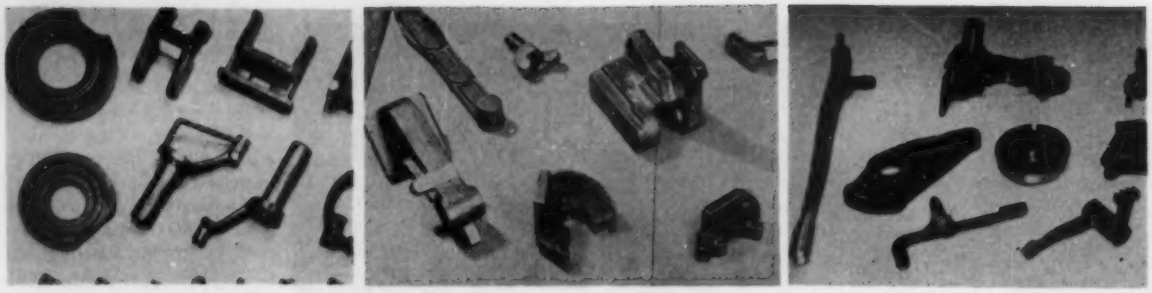
TABLE I—Composition of Ductile Iron

Total Carbon	Silicon	Manganese	Phosphorus	Sulfur	Nickel
3.0–4.0%	2.0–3.0%	0.2–1.0%	0.08% max.	0.02% max.	0.0–3.0%

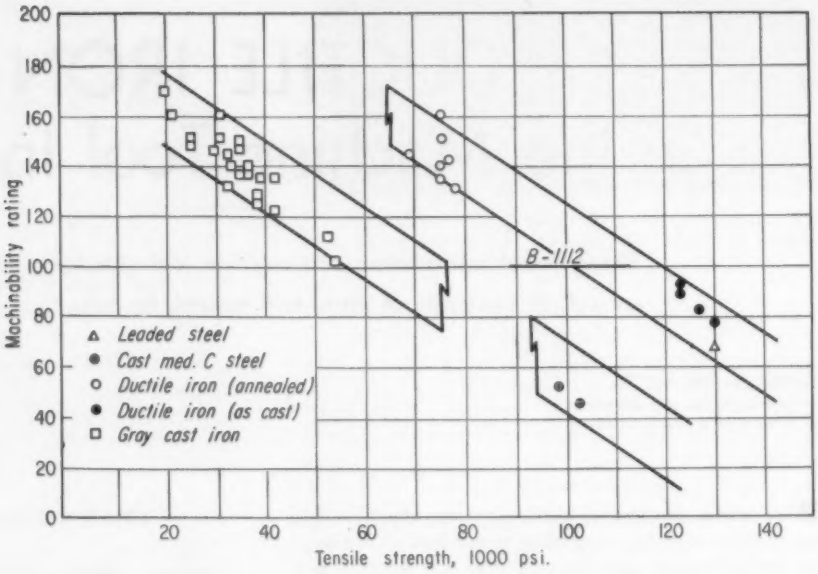
MECHANICAL STRENGTH

With proper control of chemical composition, ductile iron castings can be produced to minimum tensile strengths ranging from 60,000 to 120,000 psi in the as-cast condition. However, for heavily stressed applications and particularly where impact is involved, heat treating is customary. This permits tensile strengths from 60,000 to 175,000 psi with elongations as high as 30% at the lower strength levels.

All of the common heat treatments used for steel are possible, including stress relieving, annealing, normalizing and tempering, and quenching and tempering. Austempering and martempering are also practiced. Surface harden-



Machine tool parts . . .
of ductile iron are used for fatigue strength, rigidity, and production economy. Shown left to right are: miscellaneous castings for tool room lathe parts for Pratt & Whitney Co., Inc., components of turret lathes used by Warner & Swasey Company; and miscellaneous automatic screw machine castings used by Brown & Sharpe Mfg. Co.



Machinability ratings . . .
of ductile iron, cast iron and steel. At higher strength ferritic and pearlitic ductile iron machines as readily as lower strength gray iron.

ing by flame or induction heating techniques is commonly used, but for best response the structure of ductile iron should be pearlitic with a substantial amount of carbon in the combined form.

Occasionally it is desired to impart increased hardenability to ductile iron so that heavy sections can be through-hardened by quenching or normalizing, or higher hardnesses and strengths can be developed as-cast with the necessity of heat treatment. Alloying additions of nickel or molybdenum, either singly or in combination, are effective for these purposes.

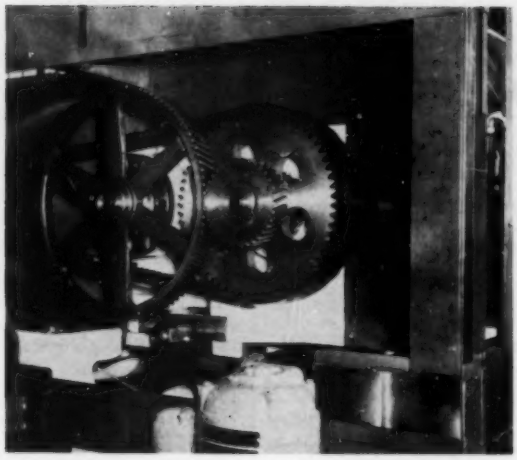
ENDURANCE STRENGTH AND RIGIDITY

Components of automatic screw machines are typical examples of parts which must withstand high cyclical stresses and must maintain a minimum amount of deflection under load. Thus the material used must have a high endurance strength along with a high modulus of elasticity. The generally complex shapes of the parts make their production by casting particularly attractive.

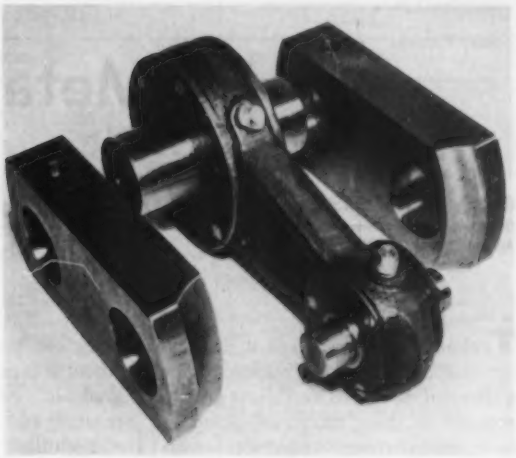
Ductile iron castings as replacements for wrought steel components on a screw machine include trip levers, lead levers, reversing cam lever, clutch fork and others. All of these components must possess high resistance to fatigue, good rigidity, economy of manufacture, that are possible with type 60-40-15 and 80-60-03 ductile iron castings.

In its elastic behavior, ductile iron resembles steel. It exhibits a proportionality between stress and strain. Therefore, it possesses a proportional limit, as well as a true modulus of elasticity which is measured at 25 million psi, as compared with 30 million psi for steel. Moreover, parts made of ductile iron regularly realized the full potential of this modulus value because of the excellent castability of ductile iron minimizes conditions of unsoundness that effectively reduce stiffness.

Associated with the elastic properties is vibration damping capacity. This property for ductile iron is greater than for cast steel but less than for gray iron, when compared at equal hardnesses. A strong material with improved damping capacity is of importance in the reduction of vibration and resonant stresses in rotating parts, in reducing tool chatter, and in reducing gear noise.



Change gear . . .
used on New Britain Machine Co. chucking machine. Superior wear resistance is a major factor in the acceptance of ductile iron for gear material.



Crank disks . . .
of ductile iron replaced hardened steel on a textile machine. Hardened properties of the iron are: tensile strength, 130,000 psi; elongation in 2 in., 1.5%; Brinell hardness, 321.

MACHINABILITY

An outstanding quality of ductile iron is its machinability. When consideration is given to such factors as quality of surface finish, tool life and rate of metal removal, it is superior to both gray iron and steel. In fact, often times the overall cost of a finished component is reduced because of these advantages even though other materials may be lower in initial cost. The adoption of ductile iron has resulted in savings of as much as 60%; and 20 to 25% savings are common.

A summary of results of laboratory machining tests indicate the machinability of ductile iron. From these data it may be concluded that ferritic ductile iron with a tensile strength level of 60,000-75,000 psi machines as readily as 25,000 psi tensile strength gray iron; also that pearlitic ductile iron at a 120,000-130,000 psi strength level machines as easily as a 60,000 psi gray iron.

WEAR RESISTANCE

In common with good quality gray iron of proper microstructure, ductile iron has excellent wear resistance. As with gray iron, wear resistance is associated with the self-lubrication provided by the contained graphite which smears the wearing surfaces and aids in establishing a glazed film. The degree of wear resistance is dependent upon the hardness and may be improved as surface hardness level is increased.

Its outstanding wear resistance has been a major factor in the acceptance of ductile iron as a material for gears. An example is the ductile iron change gears transmitting 22 hp on a large chucking machine. These gears are supplied by the foundry in the normalized condition at a specified hardness between 225 and 250 Brinell. Gears range in size from 16 to 26 in. diameter.

PRESSURE TIGHTNESS

Ductile iron is similar to gray iron in its castability. It possesses a low melting point and exceptional fluidity. Consequently, it is particularly suited to the production of intricate pressure castings where high mechanical properties are required.

Often a part is too complex to be practical in cast steel and would have inadequate mechanical properties when cast in gray iron. Ductile iron in general, therefore, offers attractive possibilities for pressure castings because—if properly fed—the castings will be pressure tight. The separate spheroids of graphite preclude the possibility of "weeping" which is frequently met with gray iron if interconnecting graphite flakes offer paths by which fluid under pressure can penetrate the casting wall.

FLEXIBILITY OF DESIGN

A major factor in designing a small intricate machine tool part is the degree of freedom available to design for maximum efficiency. The excellent fluidity and castability of ductile iron allows the placement of metal at the best location for maximum rigidity and strength. Valuable weight savings can be realized by using a material that can be cast into intricate shapes allowing metal to be placed only where it is needed.

Metal chips are one of the largest wastes of material in industry. Savings can be realized, therefore, when a ductile iron casting replaces a forging that cannot be produced as close to final dimensions.

Another factor is the ability to construct a model machine and, if necessary, to be able to modify the design of a particular part at only small cost. Ductile iron castings provide the needed flexibility for a casting pattern to be revised at moderate cost.

REFERENCE:
Ductile Iron in the Machine Tool Industry by Robert M. Bronson, Chicago Technical Field Section, Development & Research Division, The International Nickel Company, Inc. Published in INCO, Volume 27, No. 3, April 1958, p 11-15.

From: Frontier

Metals for Tomorrow

DR. D. J. McPHERSON
Director, Metals Research Division
Armour Research Foundation

Materials that today crack at room temperature, oxidize too fast, cost too much, show promise as structural metals—in the tonnage class.

Technological development in this age of speed, space and nuclear power is demanding metals and alloys greatly superior in three categories—alone or in combination: lightness – with strength; heat resistance – retaining strength at very high temperatures; and special nuclear properties. Many of the considered metals are reactive –having undesirable high-temperature oxidation; some are refractory–having desirable high melting points; nearly all are expensive.

Included are beryllium, titanium, vanadanium, chromium, zirconium, columbium, molybdenum, tantalum and tungsten, with hafnium and rhenium being explored but eliminated from tonnage listing because of ore scarcity. The remaining metals have one or two basic problems. First, reactivity with gases in the atmosphere makes extraction, melting and mill processing difficult and expensive, and limits the use for high-temperature air service. Other problem is brittleness, which makes fabrication difficult at room temperature.

Beryllium has been used mainly as a precipitation hardening agent in berylium-copper. Pure beryllium metal has become more important because of its low neutron-capture cross section. Instead of removing neutrons by capture in nuclear applications, beryllium slows down or bounces the neutron back to help maintain the fission process.

Among its good properties are density almost as low as magnesium–about half aluminum–but a much higher melting point than either. Major problem: brittleness at room-temperature. Alloying does not help room-temperature ductility because of a very low solubility for other elements.

Titanium is closest of the metals to being a tonnage structural metal. About a dozen alloys are commercially available. Metal is light, corrosion-resistant and strong.

Technical problems are less serious than with other metals. High cost is not in the sponge but in the mill products as titanium is highly reactive. Possible answer: produce semi-finished mill shapes by directly extruding sponge or powder in protective sheaths. Developing a direct extractive process for alloyed sponge or powder would be required as a corollary but metallurgists feel both of these processes can be developed.

Vanadium is potential competition for titanium and stainless steel in aircraft and missiles, for the super-alloys in 1600 to 1800 F service, and for other materials in atomic reactors.

Advantages include: relatively high melting point and relatively low density–about midway between titanium and steel. It is stable in air up to 1250 F; thermal conductivity is double stainless and titanium; weld ability is excellent. Its strength is nearly as great at 1000 F as it is at room-temperature.

Outstanding property of vanadium-base alloys is the excellent retention of hot strength up to 1200 F, with protective coatings extending service to about 1800 F. Metal and its alloys are easily fabricated. Almost catastrophic oxidation occurs above 1250 F but substantial improvements are certain through alloying.

Chromium has excellent oxidation resistance to very high temperatures and good load carrying ability at high temperatures. Its application is in extending the temperature range of the super-alloys to 1800-2000 F.

Brittleness is the major problem of the chromium-base alloys. Nitrogen is the cause and although several solutions are available none seem promising for large-scale production.

Brittleness caused by a single impurity can be attacked in several ways including rheotropic recovery–prestraining a brittle metal above its ductile-to-brittle formation temperature, and so, depressing its transistion temperature. This method has produced torsional but not tensile ductility in cheap electrolytic chromium.

Zirconium alloys developed for pressurized-water reactor use are the Zircaloy group–very dilute alloys containing tin and iron for corrosion resistance. Much stronger alloys, good for service up to 1500 F in absence of air, have been laboratory developed.

Columbium is a sister metal of tantalum–invariably they occur together and separation is difficult. Metal is needed for its moderately low neutron-capture cross section, high strength at high temperatures, ability to form useful alloys with uranium, resistance to corrosion in some liquid metals and ease of fabrication.

Properties, however, vary with production method. Oxygen makes the metal harder and stronger and eventually brittle. Columbium has two distinct advantages over molybdenum: a lower density; although gas-sensitive, it does not oxidize castastrophically like molybdenum. When coated, even if the coating ruptures, there would be a reasonable time lapse before failure of the part.

Two aims of alloying columbium are stronger high-temperature alloys (2400 to 2500 F), and oxidation-resistance to avoid coatings. First is possible, second, highly doubtful.

Molybdenum is being processed on a tonnage basis by arc-casting. Out-

Potential Structural Metals

Name	Atomic No.	Density, lb/cu in.	Melting Point, F	Modulus of Elasticity × 10^6, psi	Ultimate Tensile Strength, psi	Yield Strength, psi	Elongation, % in 2 in.	Electrical Resistivity at 20 C, microhm/cm	Lin. Coeff. of Exp. at 70 F × 10^{-6}	Thermal Conductivity, cal/sq cm/sec/C/cm	Price, $/lb	Relative Abundance (copper = 100)	Neutron Capture (barns)	Uses
Beryllium	4	0.07	2345	44	35,000 to 95,000	30,000 to 45,000	2 to 20	4	7.1	0.385	47 to 75	8.6	0.009	Nuclear reactor moderators and reflectors (1) Airframe members.
Titanium	22	0.17	3074	15.5	50,000 to 80,000	40,000 to 70,000	20 to 60	47.8	5.2	0.41	6 to 11	6500	5.6	Aircraft. Nearest to high tonnage production. (1) Commercial transportation and marine.
Vanadium	23	0.22	3452	20	55,000 to 75,000	40,000 to 65,000	16 to 33	24.8	5.0	0.074 to 0.088	79 to 80	300	4.7	Not in tonnage production. (1) Airframe member; atomic reactors.
Chromium	24	0.26	3410	42	80,000	52,000	0 to 48	13.0	3.5	0.16	1.30 to 5.50	290	2.9	(1) High-temperature heat engines and structures.
Zirconium	40	0.235	3380	11	49,000	29,000	18 to 31	45	5.0	0.4	20 to 35	250	0.18	Fuel sheathing, construction materials in nuclear reactors. Chemical-corrosion field. Moderately large-scale production.
Columbium	41	0.31	4380	12.4	50,000	24,000	40	14.2	4.0	0.13	55 to 85	34	1.1	Nuclear-reactor fuel alloy. (1) High-temperature heat engines and structures.
Molybdenum	42	0.37	4750	46	65,000 to 175,000	50,000 to 150,000	1 to 15	5.17	3.0	0.346	6 to 25	21	2.4	Tonnage production possible. Electronic applications. (1) High-temperature heat engines and structures.
Tantalum	73	0.60	5425	27	50,000 to 150,000	39,000	40	12.4	3.6	0.13	50 to 60	3	21.0	Special corrosion applications; electronic tubes; rectifier or capacitor material. (1) Base for high temperature alloys.
Tungsten	74	0.70	6150	50	70,000 to 300,000	.....	0	5.5	2.2	0.31	8	92	19.0	Electrical, electronic applications. (1) High-temperature heat engines and structures.

1) Possible future uses.

Product Engineering

standing properties are high melting point and alloys with better elevated temperature strengths than any existing metallic material.

Only non-heat-treatable, very dilute alloys have been developed commercially. Molybdenum is relatively cheap compared to other highly refractory metals. Disadvantages: high reactivity with gases at high temperatures and room temperature brittleness unless specially processed.

Solution to the problem of protecting molybdenum from oxidation is the major problem. Alloying is not sufficient. A pinhole in coating or cladding may allow complete deterioration of the structure. Most promising solution appears to be sprayed or electroplated multilayer coatings of nickel and chromium, plus diffusion treatment.

Tantalum currently is used in special corrosion applications where the need justifies the price, for example, in electronic tubes and as rectifier or capacitor material. Its alloys may be stronger at very high temperatures than any structural material except tungsten.

Tantalum density is high, strength about the same as molybdenum at room temperature and up to 1800 F neutron-capture cross section is high, making the material highly useful in nuclear applications.

Tungsten is now used for its electrical and electronic properties. It has the highest melting point and re-crystallization temperature (2700 F) of all metals and it is the heaviest of the group under consideration.

Tungsten alloy development is just starting and will undoubtedly be aimed at developing super-strength refractory structural alloys. This metal oxidizes catastrophically like molybdenum, and a coating system of the type for molybdenum is needed before it is commercially used.

FOR MORE DATA:

Here is a selection of sources for information on each of these metals. Research institutions and government agencies also can supply much useful data.

Beryllium

Beryllium Corp. of America, P.O. Box 1462, Reading, Penna. Brush Beryllium Corp., 4301 Perkins Avenue, Cleveland 3.

Columbium

Electro Metallurgical Co., Niagara Falls, N. Y. Fansteel Metallurgical Corp., North Chicago, Ill. E. I. duPont, Wilmington, Del. Kennametal, Inc., Latrobe, Penna. Kawecki Chemical Co., Boyertown, Penna. Molybdenum Corp. of America, Pittsburgh. Wa Chang Corp., Albany, Oregon.

Chromium and Vanadium

Electro Metallurgical Co. Vanadium Corp. of America, 420 Lexington Ave., New York 17.

REFERENCE:
New Day for Newer Metals by D. J. McPherson. Published in ARF *Frontier*, Fall, 1958, p 4.

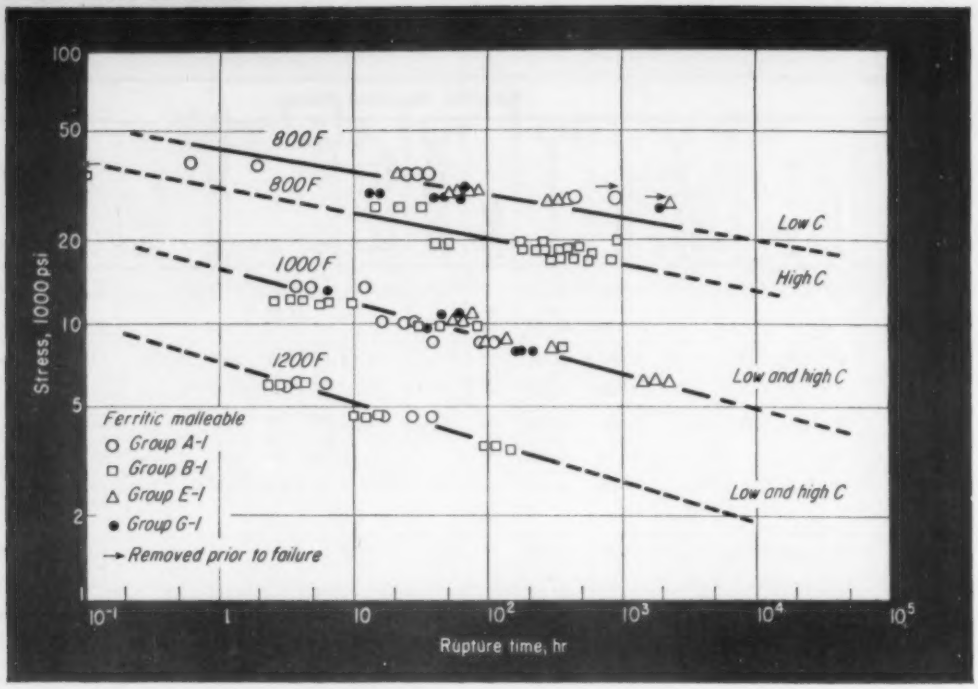


Fig. 1—Stress-rupture plot for ferritic malleable iron.

From: ASTM paper

Malleable Iron at Elevated Temperature

Experimental data on high temperature stress-rupture and creep properties of unalloyed malleable irons. Ferritic and pearlitic materials at temperatures ranging to 1200 F for times up to 2300 hr. Results indicate a high level of performance to be expected although data are not yet complete.

LAURISTON C. MARSHALL, Director of Research
GEORGE F. SOMMER, Research Engineer
Link-Belt Company

Although considerable information is available on the tensile properties of malleable iron at room temperature, relatively little is known concerning elevated temperature properties. Results of the few high temperature studies are limited to short-term properties in tension over a temperature range from about 75 to 1200 F. Although of help, this information is inadequate for designing equipment intended to operate for prolonged intervals at elevated temperatures.

Here, some knowledge of the stress-rupture properties is essential; and if deformation is important, observations of creep behavior are necessary. Research is going on to obtain adequate design information to assist in applying ferritic and pearlitic malleable irons to uses requiring load-carrying ability for long periods at elevated temperatures.

Such data are needed for a variety of typical compositions and at the maximum temperatures for which the materials appear to be promising. Stress-rupture and creep data have been obtained together with metallographic studies of the failed test specimens on high and low carbon analysis standard ferritic malleable and pearlitic malleable iron. Table I gives the chemical analyses of the representative irons. Two groups are apparent; low carbon (2.00-2.45 C) and high carbon (2.30-2.70 C). Ferrite and pearlitic malleable irons are represented by these two groups.

RESULTS OF TESTS

The stress-rupture plots for low carbon ferritic malleable irons at 800 F, high carbon ferritic at 800 F and both high and low carbon ferritic malleable irons combined at 1000 and 1200 F are shown in Fig. 1, and are based on least squares fits to the data using a standard regression analysis. The calculations also yield values of the intercepts at 1, 100, 10,000 and 100,000 hr. These have been used in fitting the curves to the data showing the extrapolations at 10,000 hr. The calculated 100,000 hr values are given in Table II.

The data obtained with these standard malleable irons indicate a general high level of performance equal or superior to other ferritic materials for which data are available, particularly at 800 F. The strength at 1000 F is adequate for many applications; strength is retained even at 1200 F.

There is no indication of changes in structure or performance during the test periods which extend from about 1 to over 2000 hr. All the data thus far exhibit a good linear fit on the log-log plots, with no breaks in slope of the curves as might be expected if fundamental changes are taking place. Metallographic examination confirms this.

Data for both low and high carbon ferritic malleable appear to group closely at 1000 and 1200 F. At 800 F, however, a divergence is apparent with the high carbon material exhibiting shorter life at comparable stresses. Allowable working stresses for this material must, therefore, be reduced in comparison to low carbon malleable as shown in Table II. Still the high carbon material has promise for use in load-carrying applications at 800 F and is equal in performance to other unalloyed ferritic materials.

Data available on two groups of low carbon pearlitic malleable irons are shown in Fig. 2. At 1000 F, rupture stress levels are superior to the ferritic malleables at the same temperature; but slightly less than for low carbon ferritic at 800 F.

Points for the pearlitic irons at 800 F, are also shown in Fig. 2, indicating a minimum performance superior, but very similar to the low carbon ferritic material at the same temperature. On the basis of other tests, the pearlitic irons appear equal to alloyed high carbon materials containing as much as 0.5% molybdenum. In other comparisons, the pearlitic irons tested appear superior to other unalloyed cast pearlitic irons and equal or superior to most alloyed cast irons.

Table II, as mentioned, compares the properties of all the materials tested. Stress levels given are calculated intercepts at 1, 1000, 10,000 and 100,000 hr. The 10,000 hr values of ferritic malleable irons at 800 and 1000 F and pearlitic at 1000 F, although extrapolated, are considered reasonable based on the close straight line fit and the absence of any evidence of transitional changes in the material or breaks in the curves.

The 100,000 hr extrapolations may be valid for the same reasons. The values are included, however, primarily for comparison with other materials. It is believed, however, that the stress values given may constitute a reasonable index of the average performance to be expected of the material if applied with suitable caution.

ELONGATION MEASUREMENTS

Typical time-elongation curves for several groups of ferritic and pearlitic malleable irons are shown in Figs. 3, 4 and 5. These clearly exhibit the

TABLE I—Chemical Analyses of Test Specimens

Material	Composition, % C	Si	Mn	S	P	Cr
Ferritic (low carbon)						
Group A-1	2.26	1.09	0.29	0.074	0.148	.....
E-1	2.16	1.17	0.38	0.095	0.137	0.017
G-1	2.29	1.01	0.38	0.086	0.11	.....
Ferritic (high carbon)						
Group B-1	2.50	1.32	0.43	0.159	0.024	0.029
Pearlitic (low carbon)						
Group E-2	2.27	1.15	0.89	0.098	0.135	0.019
G-2	2.29	1.01	0.75	0.086	0.11	.....

TABLE II—Calculated Values of Stresses for Times to Rupture

(*Extrapolated values for 10,000 and 100,000 hours are provisionally included*).

Group	No. of Observations	Rupture Time, hr	Initial Stress, psi	Minimum Rupture Time, 95% Confidence, hr[a]
CALCULATIONS FROM LOG-LOG DATA				
Ferritic (low carbon) groups A-1, E-1, G-1 at 800 F (Fig. 1)	10	1	42,150	.....
		1000	24,400	135
		10,000	20,350	990
		100,000	16,950	15,050
Ferritic (high carbon) group B-1 at 800 F (Fig. 1)	21	1	31,000	.....
		1000	17,000	280
		10,000	14,000	2580
		100,000	11,400	21,900
Ferritic (high and low carbon) groups A-1, E-1, G-1, B-1 at 1000 F (Fig. 1)	35	1	15,700	.....
		1000	6,650	480
		10,000	4,990	4470
		100,000	3,750	41,000
Ferritic (high and low carbon) groups A-1 and B-1 at 1200 F (Fig. 1)	15	1	7,350	.....
		1000	2,680	335
		10,000	1,920	2550
		100,000	1,370	18,600
Pearlitic groups E-2 and G-2 at 800 F (Fig. 2)	23	1	52,460	.....
		1000	37,140	130
		10,000	33,100	1050
		100,000	29,500	7750
Pearlitic (low carbon) groups E-2 and G-2 at 1000 F (Fig. 2)	20	1	27,400	.....
		1000	10,300	380
		10,000	7,380	3450
		100,000	5,320	29,900

[a] Calculated from actual data by standard regression analysis and based on sample number shown in Col. 2.

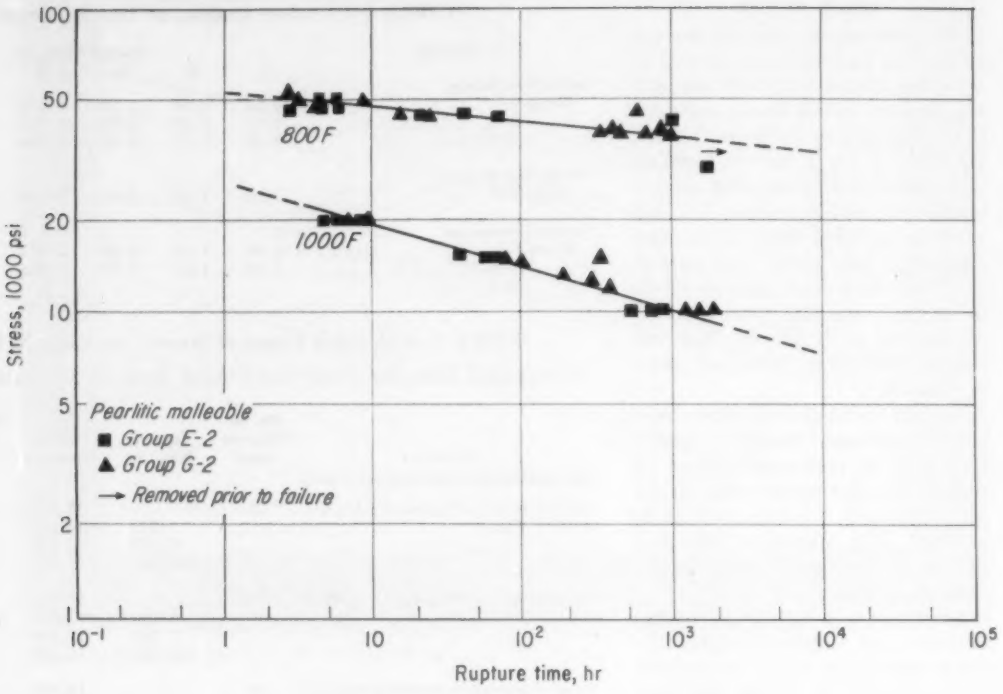


Fig. 2—Stress-rupture plot for pearlitic malleable iron.

three stages reported in the literature.

Changes which occur in the shape of the curve at different loads for two groups of ferritic specimens, are shown in Fig. 3. Values obtained for the minimum creep rate (linear or second stage portion) vary from 0.0017% per hr for long rupture times to 4% per hr at the highest stress levels and short times. It should be noted that the long-time test at 25,000 psi is from a different group than the other two curves shown. These two groups showed different elongation values at 800 F so it is not to be concluded that any loss of ductility occurred.

Elongation behavior at 1000 F for both ferritic and pearlitic material are shown in Figs. 4 and 5. Approximately 50% of the elongation occurs in the first two stages of creep, which frequently account for the useful life of a part in service. The third stage is generally so rapid that a part would not be useful under such conditions. This 50% elongation generally occurs in about 70% of the time to failure. This time value varies from about

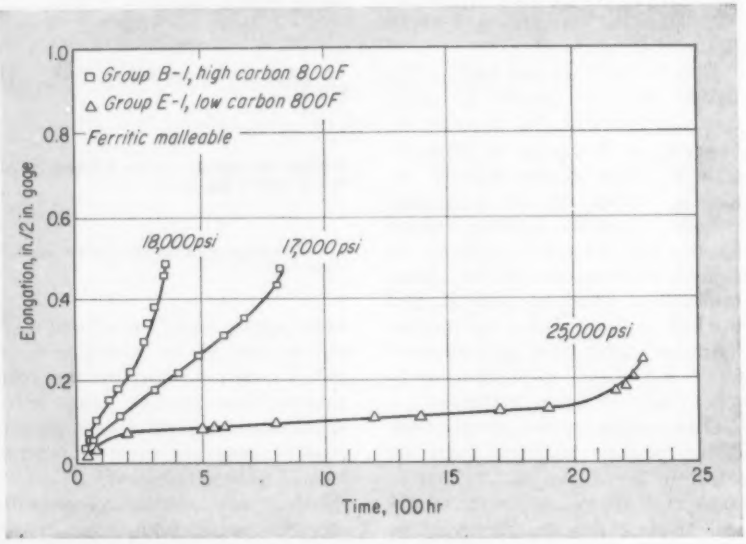


Fig. 3—Time-elongation curves for ferritic malleable iron at 800 F.

60% at higher loads and temperatures to over 80% for longer time tests.

Extension measurements actually represent the sum of elongation due to creep as well as that which might result from growth of the specimen such as might be caused by oxidation. Examination of microstructures and measurements on test specimens indicate that growth is not significant.

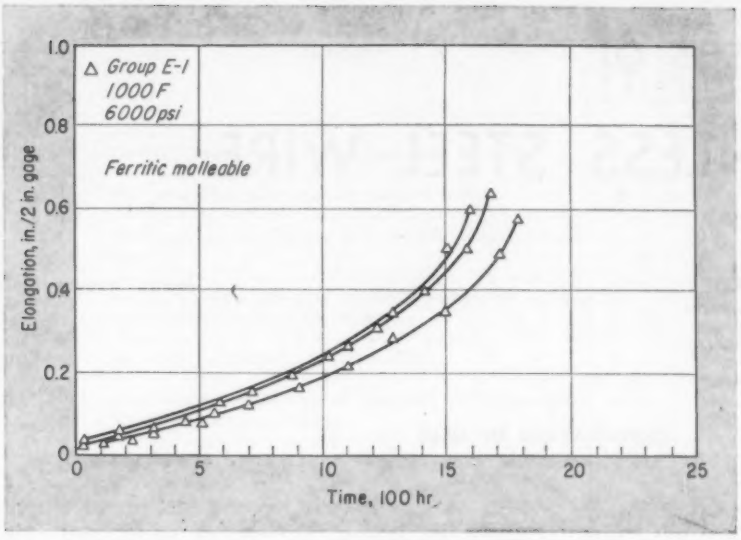


Fig. 4—Time-elongation curves for low carbon ferritic malleable iron at 1000 F and 6000 psi.

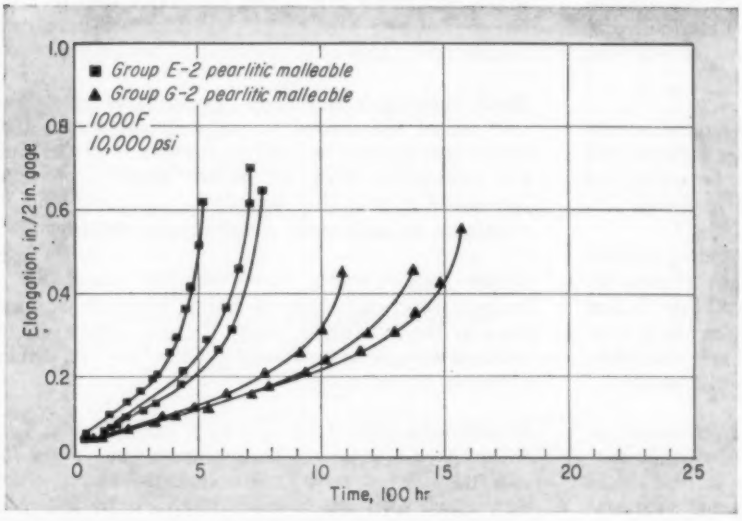


Fig. 5—Time-elongation curves for two groups of pearlitic malleable iron at 1000 F and 10,000 psi.

The rapid elongation occurring in the third stage of creep is assumed to be caused by the increase in stress resulting from reduction of area because of the extremely ductile behavior exhibited by malleable iron. The third stage portion can in some instances be obtained as the result of structural changes from materials exhibiting rather low elongation. This is not the case as shown by the tests with either pearlitic or ferritic malleable iron.

CONCLUSIONS

In the case of standard ferritic malleable irons these experiments and measurements have yielded data which make it possible to specify levels of stress at high temperatures for reasonable periods of service.

Data for the ferritic materials at 800 and 1000 F are regarded as sufficient in quantity for reliable statistical analysis and determination of loads to be carried in engineering applications.

There appears to be a distinct separation in performance at 800 F exhibited by low carbon ferritic malleable iron, which is considerably superior in load carrying capacity at this temperature to high carbon material.

Metallographic examination at standard magnifications with conventional methods yields no information bearing upon the above difference in behavior.

High and low carbon ferritic malleables are indistinguishable in performance at 1000 and 1200 F.

The data on ferritic malleable at 1200 F indicate that satisfactory load capacity exists for extended periods of time. Extension of the range of data should permit specification load values to be realized.

The data on pearlitic malleable irons indicate for some grades, a high load capacity at 800 and 1000 F; somewhat greater than for the ferritic malleable irons.

Metallographic examination reveals no significant changes in structure or character of the pearlitic malleable irons thus far tested for ranges of time over 2300 hr. Data for all the irons tested thus far both ferritic and pearlitic yield no evidence of fundamental changes in structure or physical characteristics. This is substantiated by metallurgical examination as well as there being no breaks in the curves at the longest time.

Based on these findings, it would appear reasonable to make applications of malleable irons using extrapolations of the data.

Considerable additional work is needed to complete the picture of the performance of pearlitic and ferritic malleable iron at elevated temperatures. This is proceeding.

REFERENCE:

Stress-rupture and Creep Properties of Malleable Iron at Elevated Temperatures by Lauriston C. Marshall, Director of Research, and George F. Sommer, Research Engineer, Link-Belt Company, Indianapolis, Indiana. Presented at the 61st Annual Meeting of the American Society for Testing Materials, Boston, Mass, June 1958.

Ten uses of STAINLESS STEEL WIRE

ROLAND J. BERKOL
Technical Information Service
Stainless and Strip Division
Jones & Laughlin Steel Corp.

From: Company manual

EXPLANATION OF USES

Cold Heading–Forms fasteners of all types. ½ in. dia. or less wire can be cold headed in the same equipment used for cold heading carbon steel. Annealing may be required after severe upsetting to relieve cold work stress.

Hot Upsetting–Used for forming stainless parts from wire above ½ in. dia. Process is limited only by the machine capacity. Hot upsetting does not require a lubricant coating as does cold heading to facilitate part removal from the die, thus simplifying the process.

Warm Heading–An extension of cold heading at temperatures from 500-700 F. It is a compromise between cold and hot upsetting in that it reduces scale formed by hot upsetting and decreases cold heading work hardening.

Slide Forming–Wire is shaped in a slide forming machine to form shelves, grilles, handles, etc. Formed parts are functional and stainless steel is used because of its physical and mechanical properties as well as for corrosion resistance. Parts can be given a bright finish by electrolytic polishing. 300 series formed in ⅛ to ½ hard condition.

Conveyor Belt–Wire is usually woven in a soft condition. Can handle corrosive materials at high or low temperature under all conditions. Stainless wire grade or type should be selected based on temperature, scaling and short-time hot strength for conveyor belts.

Weaving–Wire cloth and screening used as chemical filters, shaker screens and others. 300 series best for abrasive applications because impact and movement of hard particles will cause cold working increasing hardness and wear resistance of the component.

Welding–Joining of various types of stainless plates, sheets or fabricated parts. When joining carbon, alloy or clad steels to stainless, welding rods of high alloy content are required for good joints.

Spring–Austenitic and martensitic steels are used. 400 series types are supplied soft and heat treated to spring temper after forming. 300 series are formed from a high-tensile condition. Coatings are required for machine forming. Fatigue resistance improved by low temperature (400-800 F) heat treatment or shot peening.

Rope–Hard drawn wire of the 300 series is used for applications requiring high fatigue resistance such as aircraft control cable. Also used in corrosive atmospheres.

Metal Spraying–Standard and special types of stainless wire melted and sprayed on prepared cold surface from special gun directed by hand or machine. Provides stainless coatings as thick as $\frac{1}{16}$ in. Stainless properties approached on iron, steel, and others, repair and build up worn areas on parts made of stainless and other metals.

Shapes–Wire is usually drawn round by square, flat or hexagon shapes may eliminate cutting and finishing operations in the fabricator's plant. Custom shapes such as diamond wire can be produced by cold rolling with carbide wheels or by extrusion.

Miscellaneous Uses: Heat hardenable grades such as Type 440 are used to form ball bearings from wire. Types 302 and 304 with low magnetic characteristics have electrical uses. Small parts can be made from wire by rolling or extruding to shape and cutting to length.

Physical Characteristics–300 series can be bent 180° over own diameters up to ⅜ in. maximum and 250 Brinell maximum; 400 series up to 220 Brinell maximum. Tensile strength in Types 302 and 304 as high as 355,000 psi in diameters 0.009 in. and smaller can be obtained. 300 series are nonmagnetic (annealed) with an electrical resistivity approximately eight times that of carbon steels. 400 series are magnetic with a lower resistivity.

REFERENCE:
Stainless Steel Wire Manual Jones & Laughlin Steel Corp., Stainless and Strip Division, Detroit, Michigan.

AISI TYPE NUMBER	PURPOSE	Cold Heading	Conveyer Belt	Rope	Hot Upsetting	Slide Forming	Weaving	Welding	Spring	Winding	Metal Spraying
202	General purpose low nickel equivalent to Type 302.....	A	A				A		B		
302	The general purpose austenitic stainless steel.	A	A	A		A	A		A		
303	Free machining modification of Type 302 for severe upsetting.	C			A						
303Se	Free machining modification of Type 302 where hot working and cold heading may be involved.	C			A						
304	Low carbon modification of Type 302.	B	A	A		A	A		A	A	A
304L	Lower carbon modification of Type 304 for further restriction of carbide precipitation.	A						A			
305	Low work hardening rate used for spin forming and severe drawing operation.	A									
308	Higher alloy steel having higher corrosion and heat resistance.							A			
309	Used for its high temperature strength and scale resistance.		A				B	A			
310	Higher elevated temperature strength and scale resistance than Type 309.	B	A				B	A			
310Mo	Special welding rod grade.							A			
312	Special welding rod grade.							A			
316	Higher corrosion resistance than Types 302 and 304. High creep strength.	A	A	B			A	A	B	A	A
316L	Low carbon modification of Type 316.	A						A			
321	Stabilized for resistance to highly corrosive conditions and for service in 800 to 1600 F temperature range.		A								
347	Same as Type 321.	B	A					A			
410	General purpose heat treatable stainless steel.	A	A			A		A	B		
416	Free machining modification of Type 410 for severe upsetting	C			A						A
416Se	Free machining modification of 410 for hot or cold heading.				A						
420	Higher carbon modification of Type 410 often used for cutlery, surgical instruments, valve and other wear resisting parts.	B							A		A
430	General purpose non-hardenable chromium stainless steel.	A	A			A	B	A			
430F	Free machining modification of Type 430 for heavier upsetting.	C			A						
430FSe	Free machining modification of 430 where hot working or cold heading may be used.	C			A						
431	Special hardenable steel with particularly high mechanical qualities.	B							B		
440A	Hardenable to higher hardness than 420 with good corrosion resistance.	B									

A—Preferred for most applications
B—Permissible alternate
C—Permissible under certain conditions

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(B-1) Tubing Grades—Catalog, 8 pp. Describes seamless tubing of carbon and alloy steels in mechanical, pressure and airframe grades; welded tubing of carbon steels in mechanical and pressure grades; tubing can be forged or fabricated. Ohio Seamless Tube Div of Copperweld Steel Co, Shelby, Ohio.

(B-2) Pipe and Tubing—Catalog, 32 pp. Sizes, gages and analyses of welded stainless steel piping and tubing. Gives chemical and physical properties, tolerances and weights. The Carpenter Steel Co, Alloy Tube Div, Union, NJ.

(B-3) Steel Tubing—Bulletin, 24 pp. Illustrates parts and other items fabricated from mechanical tubing. Includes data on wall thicknesses, shapes, steel grades, anneals, surface finishes and suggested uses. National Tube Div, United States Steel Corp, 525 William Penn Place, Pittsburgh 30, Pa.

(B-4) Surface-rolled Patterns—Brochure, 15 pp. Gives information about sizes, steel pattern designs, product uses, photographs of typical applications and methods of fabrication, tooling and painting. Sharon Steel Corp, Sharon, Pa.

(B-5) Steel Products—Catalog, 48 pp. Covers electric furnace steel production, melting, rolling, finishing, thermal treating and conditioning. Includes listing of blooms, billets, slabs, and bars, available in standard and special analysis. Rolling limits and chemical compositions are also presented in addition to various charts, photographs and other illustrations. Copperweld Steel Co, Aristoloy Steel Div, Warren, Ohio.

(B-6) Steel Tubing—Catalog, 12 pp. Chemical and physical properties, sizes and specifications. Plant facilities and section on tubular push rods. Avon Tube Div, Higbie Mfg Co, 4th & Wilson, Rochester, Mich.

(B-7) Sheets and Plates—Brochure, 8 pp. A description of stainless steel chemical analyses and finishes. Also limitations on Sendzimir mill and hand mill sizes. Eastern Stainless Steel Corp, PO Box 1975, Baltimore 3, Md.

(B-8) Laminated Precious Metals—Brochure, 8 pp. Describes process of manufacturing laminated metals such as precious metal overlay and inlay sheet stock and precious metal clad wire. The Improved Seamless Wire Co, 775 Eddy St, Providence 5, RI.

(B-9) Clad, Alloy and Plated Wires—Bulletin, 6 pp. Typical physical and chemical properties of cold drawn fine wire. Sylvania Electric Products Inc, 1740 Broadway, NY 19, NY.

(B-10) Textured Metal—Catalog, 32 pp. Gives the story of a design strengthened, three dimensional metal. Illustrates various applications in building, consumer goods, commerce and transportation. Forty-eight patterns are also illustrated. Rigidized Metals Corp, 220 Delaware Ave, Buffalo 2, NY.

(B-11) Ti and Zi Ingots and Castings—Brochure, 12 pp. Description of processes, illustrations of production equipment and auxiliary facilities, and pictures of some typical casting shapes. Oregon Metallurgical Corp, PO Box 484, Albany, Ore.

(B-12) Fine Resistance Wire, Bright and Enameled—Bulletin, 8 pp. Contains physical and electrical properties of fine resistance wire, bright and enameled, tables of properties and charts. Driver-Harris Co, 201 Middlesex St, Harrison, NJ.

(B-13) Alloy Wire and Ribbon—Bulletin, 9 pp. Describes physical and electrical properties of new nickel-chromium electrical resistance alloy suitable for use at high temperatures. Driver-Harris Co, 201 Middlesex St, Harrison, NJ.

(B-14) Glass-sealing Alloys—Brochure, 4 pp. Describes four nickel-iron and nickel-iron-cobalt alloys for glass-to-metal sealing of both hard and soft glass. Driver-Harris Co, 201 Middlesex St, Harrison, NJ.

(B-15) High-strength Aircraft Steels—Brochure, 29 pp. The chemistry, physical properties, heat treatment, welding, fabrication and application of high strength 5% chromium steels for airborne vehicles. Temperature graphs, hardness values and performance curves. Universal-Cyclops Steel Corp, Bridgeville, Pa.

(B-16) Copper-nickel Alloys—Catalog, 20 pp. Describes copper-nickel alloys used for electrical resistance and thermocouple applications. Contains tables showing alloy properties, thicknesses, specific resistances, list prices; also, temperature resistance curves. Driver-Harris Co, 201 Middlesex St, Harrison, NJ.

(B-17) Thermocouple Alloy—Catalog, 12 pp. Describes thermoelectric properties of new thermocouple alloys and design data for temperature measurements. Driver-Harris Co, 201 Middlesex St, Harrison, NJ.

(B-18) High-nickel Electrical Alloys—Catalog, 88 pp. Describes physical, electrical and chemical properties of nickel-chromium, copper-nickel and nickel-iron alloys. Includes tables and charts of useful data. Driver-Harris Co, 201 Middlesex St, Harrison, NJ.

(B-19) High-density Powder Metallurgy Parts—Brochure, 6 pp. The properties and advantages of high strength iron, steel and stainless steel parts from the high density powder process. It also lists the tensile properties of various materials involved. Supermet Div of Globe Industries, Inc, 1465 Cincinnati St, Dayton 8, Ohio.

(B-20) Tungsten and Titanium Carbide—Brochure, 22 pp. Physical and mechanical properties, description of typical applications, suggestions for designing with the materials. Kennametal Inc, Lloyd Ave, Latrobe, Pa.

(B-21) Magnesium and Titanium Data—Brochure, 44 pp. Engineering data and tables. Brooks & Perkins, Inc, 1956 W Fort St, Detroit 16, Mich.

(B-22) Tool Steel—Catalog, 125 pp. Analysis of typical tool failures and the reasons for each failure. For users as well as producers of tools. Bethlehem Steel Co, Bethlehem, Pa.

(B-23) Steel Plates—Catalog, 64 pp. Design information, metallurgical data, tables and diagrams, plus a complete description of Bethlehem steel plates. Full page illustrations. Bethlehem Steel Co, Bethlehem, Pa.

(B-24) Titanium—Brochure, 24 pp. Contains properties of titanium, corrosion data, welding, machining, forming techniques, in addition to other technical information. Mallory-Sharon Metals Corp, Warren Ave, Niles, Ohio.

(B-25) Fine-expanded Metal—Bulletin, 2 pp. Gives information on various small-opening materials made from thin strip by metal expanding process. Exmet Corp, 127 Marbledale Rd, Tuckahoe, NY.

(B-26) Stainless Steel—Catalog, 14 pp. Gives advantages of sheets, strip, plates, types to meet various requirements; lists and describes various types and properties, how supplied, with section on fabricating practices. Armco Steel Corp, Middletown, Ohio.

(B-27) Bismuth Alloys—Bulletin, 8 pp. Illustrated listing of 63 industrial applications for low temperature metals with a condensed table of the physical properties of 8 trade named alloys. Cerro de Pasco Sales Corp, 300 Park Ave, New York, NY.

(B-28) Brass and Copper Tubing—Brochure, 4 pp. Gives materials, finishes, thicknesses and lengths in addition to applications for typical tubing and fabricated parts. H & H Tube & Mfg Co, 263 N Forman Ave, Detroit, Mich.

(B-29) Seamless Metal Tubing—Catalog 12 pp. Describes properties, characteristics

and other technical information for various alloys and types of tubing. It further discusses the annealing, finishing and testing of tubular materials. Precision Tube Company, Inc, Church Rd & Wissahickon Ave, North Wales, Pa.

(B-30) Carbon Products—Catalog, 6 pp. Contains applications and technical information on metal impregnated graphite products such as self-lubricating bearings, electrical contacts and brushes. Metallized Carbon Co, 19 S Water St, Ossining, NY.

(B-31) Steel Tubing—Brochure, 12 pp. Describes manufacturing process of welded and brazed tubing. Provides engineering specifications, typical diameters, wall thicknesses and ordering data. Rochester Products Div, General Motors Corp, 1000 Lexington Ave, Rochester 3, NY.

(B-32) Bearing Metal—Brochure, 4 pp. Test data describing aspects of nonseizing and nonscoring aspects of material. Metal available in rough-cast bars, individual castings, centerless-ground rods, and machined parts. Bearium Metals Corp, 190 Mill St, Rochester 14, NY.

(B-33) Alloy Notebooks—1 through 9. Series dealing with metal types, properties, production methods, and other engineering data. Electric Steel Foundry Co, 2141 NW 25th Ave, Portland 10, Oregon.

(B-34) Magnesium and Aluminum Alloys—Bulletin, 54 pp. Provides information about magnesium and aluminum extruded hollow shapes, tubes solid shapes, bars, rods, strip, wire and structural shapes; as well as magnesium rolled sheet and plate. White Metal Rolling and Stamping Corp, 80 Moultrie St, Brooklyn 22, NY.

(B-35) Machinable Carbide—Bulletin, 14 pp. Describes a steel bonded, machinable carbide. Gives technical data, processing instructions, applications and ordering information. Sintercast Corp of America, 134 Woodworth Ave, Yonkers 2, NY.

(B-36) Aluminum Extrusions—Brochure, 12 pp. Supplies information to aid in selection of aluminum extrusions for specific uses: description of basic types, standard tolerances and pricing factors. Aluminum alloys are described, including mechanical specifications and recommended uses. Precision Extrusions, Inc, 729 E Green Ave, Bensenville, Ill.

(B-37) Welding Wire Comparison Chart—Bulletin, 4 pp. Details of physical properties; gives analyses, tensile strength, elongation and average hardness values. Lists typical uses of gas welding rods, bare electrodes, automatic welding and metal spray wire. Page Steel & Wire Div, American Chain & Cable Company, Inc, Monessen, Pa.

(B-38) Gold Plating—Catalog, 12 pp. Applications for gold finishes, costs, chemical features, performance curves. Engelhard Industries, Inc, 113 Astor St, Newark, NJ.

(B-39) Powdered Heavy Metal—Bulletin, 10 pp. Information on manufacturing process, applications, machinability, properties, stress-strain data. Metallurgical Products Dept, General Electric Co, PO Box 237, Roosevelt Park Annex, Detroit 32, Mich.

(B-40) Vacuum-melted Alloys—Bulletin, 8 pp. Contains general description, mechanical properties, graphs, charts and data on the pouring process. Metallurgical Products Dept, General Electric Co, PO Box 237, Roosevelt Park Annex, Detroit 32, Mich.

(B-41) Metal Ceramics—Brochure, 12 pp. Covers three grades of metal ceramics. Shows typical applications and design considerations. Haynes Stellite Co, Div of Union Carbile Corp, Kokomo, Ind.

(B-42) High-temperature Alloy—Brochure, 28 pp. Physical and mechanical properties, charts and graphs of a high temperature nickel-base alloy. Haynes Stellite Co, Div of Union Carbide Corp, Kokomo, Ind.

(B-43) Industrial Metals—Catalog, 50 pp. Describes ferrous and nonferrous, clad and solid metals for industrial uses. Applications are given as well as material thicknesses and forms available. Metals & Controls Corp, General Plate Div, 34 Forest St, Attleboro, Mass.

(B-44) Thermostat Metal—Catalog, 16 pp. Contains sheets explaining matte finish on thermostatic bimetal, standard electrical resistivity and resistance tolerances; gives composition of various types. Metals & Controls Corp, General Plate Div, 34 Forest St, Attleboro, Mass.

(B-45) Metal Laminate—Brochure, 6 pp. Describes physical and chemical properties of vinyl plastic sheeting adhesive bonded to steel, aluminum and magnesium. Includes recommended uses, colors and textures available. O'Sullivan Rubber Corp, PO Box 603, Winchester, Va.

(B-46) Stainless Steel Tubular Products—Bulletin, 8 pp. Provides technical data on analysis, corrosion and oxidation resistance, high and low temperature characteristics, physical and mechanical properties, and fabrication. Babcock & Wilcox Co, Tubular Products Div, Beaver Falls, Pa.

(B-47) Conductor Alloy—Bulletin, 2 pp. Table of conductivity and tensile properties, comparison chart, and description of applications. Surprenant Mfg Co, 172 Sterling St, Clinton, Mass.

(B-48) Embossed and Vinyl-coated Metals—Brochure, 24 pp. Describes services, raw materials, structural shapes and plant facilities. Sun Steel Co, 1700 W 74th Pl, Chicago, Ill.

(B-49) Brass and Aluminum Laminates—Brochure, 4 pp. Describes materials, construction, tensile strength and tolerances. Also lists widths and specifications. The Staver Co, Inc, 41 N Saxon Ave, Bay Shore, NY.

(B-50) High-strength Steel—Brochure, 24 pp. Contains engineering data on the high strength, structural engineering, fatigue, tensile, notched, low and elevated temperature properties; recommended hardening and surface treatments, fabrication and welding. Vanadium-Alloys Steel Co, Latrobe, Pa.

(B-51) Insulating Compounds—Bulletin, 3 pp. Describes performance characteristics of irradiated wire and cable insulation. Also materials, soldering data and tables. Surprenant Mfg Co, 172 Sterling St, Clinton, Mass.

(B-52) Sintered Metal Parts—Bulletin, 4 pp. Describes advantages of process, equipment and facilities, typical parts and economics of their use. Burgess-Norton Mfg Co, 737 Peyton St, Geneva, Ill.

(B-53) Cobalt Base Alloy—Brochure, 59 pp. Contains information on manufacture, applications and properties. Stress-rupture diagrams, temperature charts and technical bibliography are included. Cobalt Information Center, Battelle Memorial Institute, 505 King Ave, Columbus 1, Ohio.

(B-54) Low-melting Alloys—Bulletin, 36 pp. Characteristics, properties, uses, composition, various melting points of fusible alloys. American Smelting and Refining Co, 120 Broadway, NY 5, NY.

(B-55) Industrial Wire Cloth—Catalog, 71 pp. Contains specifications, glossary of wire cloth terms, selection chart and tables. Newark Wire Cloth Co, 351 Verona Ave, Newark 4, NJ.

(B-56) Steel Tubing—Catalog, 12 pp. Describes facilities and technical data on steel tubing sizes ⅛ in.-¾ in. Also tubular push rods. Avon Tube Div, Higbie Mfg Co, 4th & Wilson, Rochester, Mich.

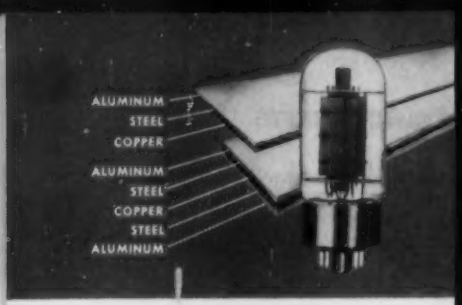
(B-57) Clad Steels—Brochure, 28 pp. Describes manufacture, properties, types and thicknesses of cladding. Also discusses testing, design considerations and applications. Koven Fabricators, Inc, 90 E Dickerson St, Dover, NJ.

(B-58) Magnetic-shielding Alloys—Brochure, 31 pp. Technical manual giving engineering information on all phases of magnetic shielding. Magnetic Shield Div, Perfection Mica Co, 1322 N Elston Ave, Chicago, Ill.

(B-59) Steel Bars—Catalog, 23 pp. Specifications on tensile strength, hardness, machinability, chemical makeup, sizes, and tolerances are given. Illustrated with charts and photographs. La Salle Steel Co, 1412 150th St, Hammond, Ind.

(B-60) Powdered Metal Parts—Catalog, 57 pp. Design and materials data, physical characteristics, charts and applications. Keystone Carbon Co, 1935 State St, St Marys, Pa.

(B-61) Zinc-coated Steel Sheets—Brochure, 20 pp. Governs characteristics and applications of electrolytic and other galvanized hot dipped types. Shows production procedures and facilities. Weirton Steel Co, Div of National Steel Corp, Main St, Weirton, West Va.



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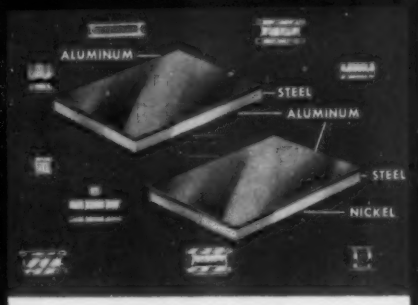

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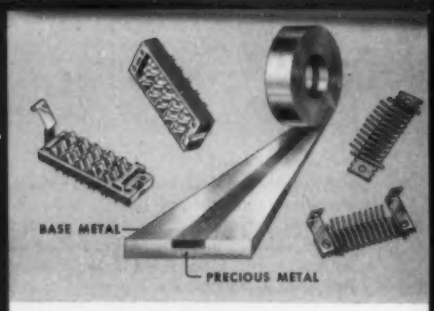

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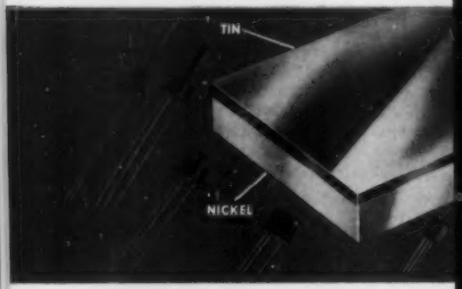

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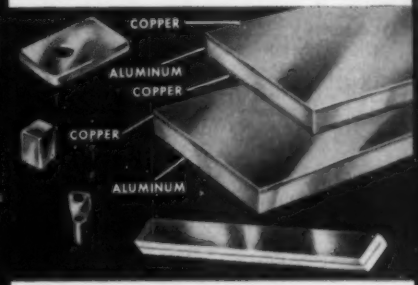

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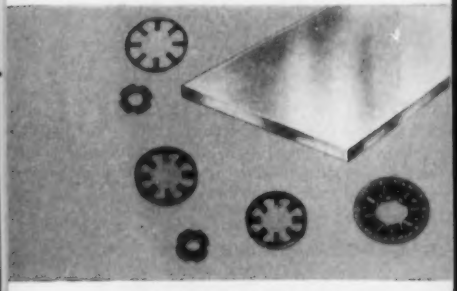

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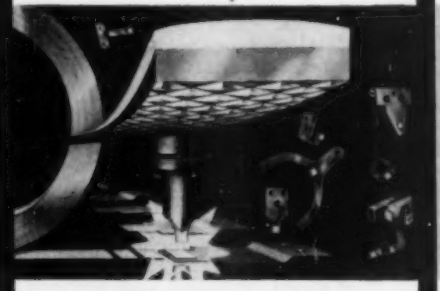

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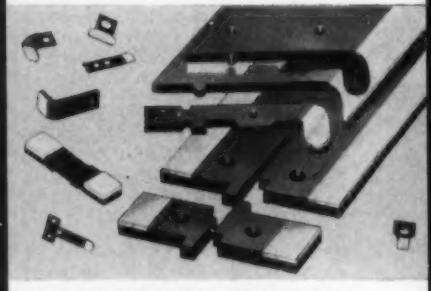

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Please send the following literature:

- ☐ *How to make your own machine and repair parts quicker and easier*
- ☐ *Wall chart listing 241 AISI grades of cold-finished steel bars*
- ☐ *La Salle Leaded Steels*
- ☐ *A new material . . (the story of FATIGUE-PROOF steel bars)*
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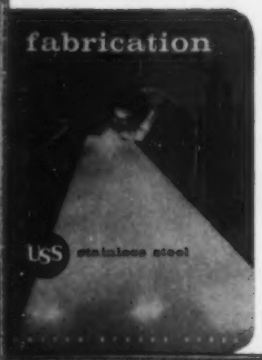

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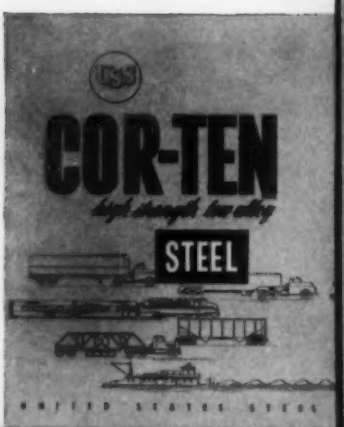

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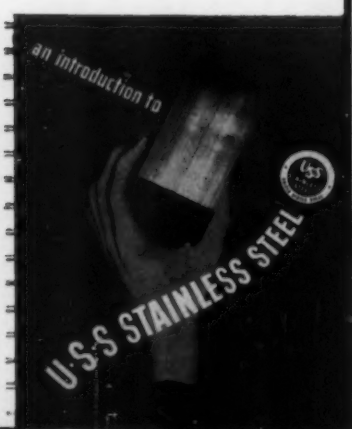

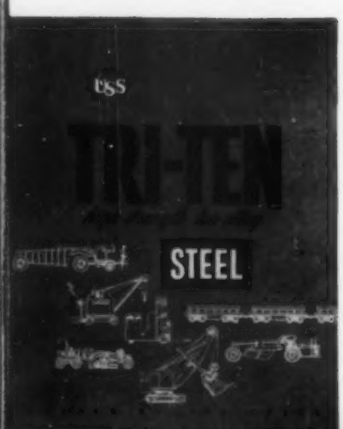

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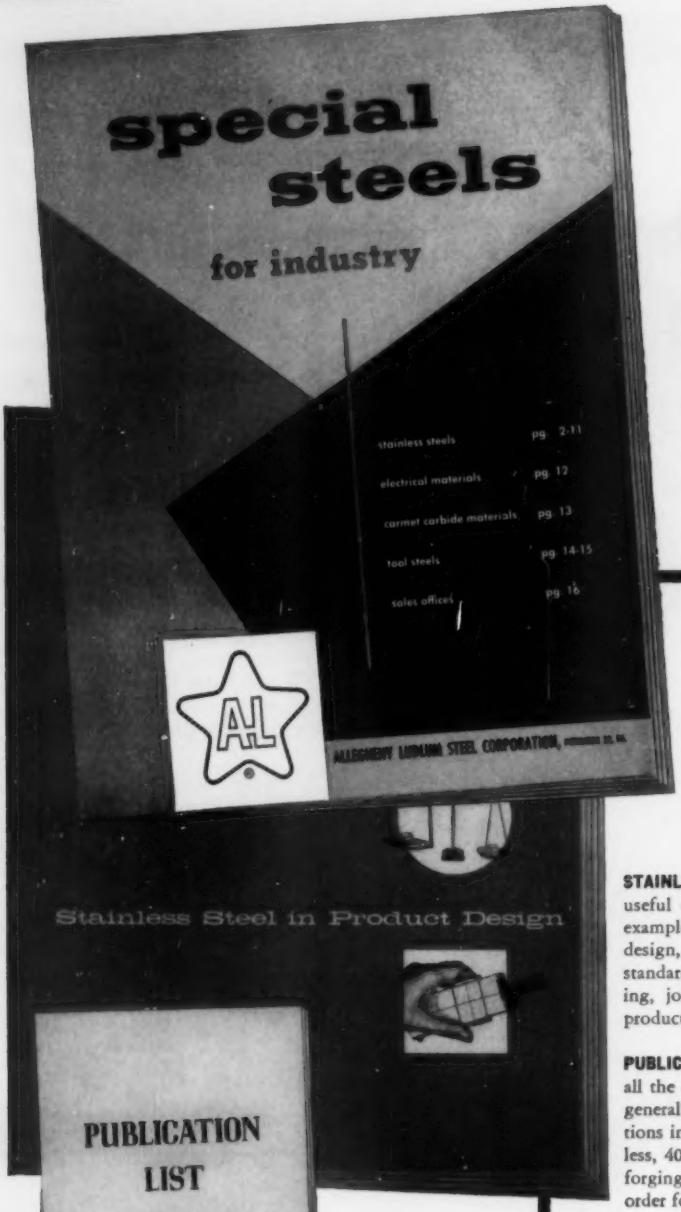

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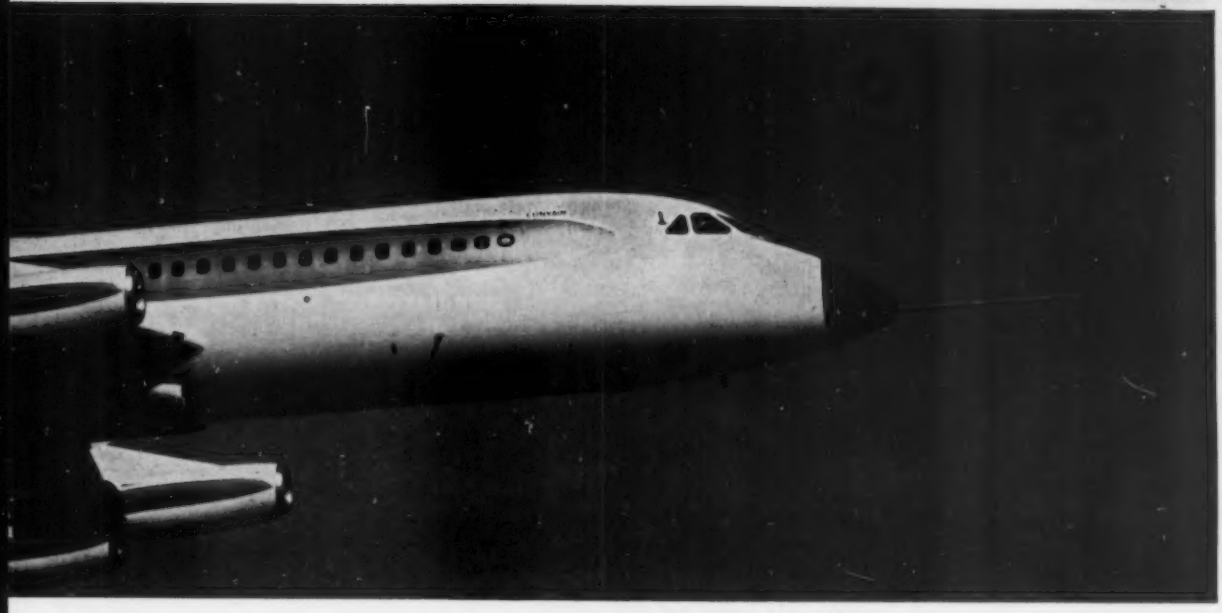

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IN EACH 880 POD-PYLON, rear engine mount "horseshoe" frame — of nickel-plated, chrome-alloy steel — grips the powerful General Electric CJ-805-3 engine. Republic Alloy Steels offer exceptionally high strength-to-weight ratios with the highest strength values. Uniform response to heat treatment assures complete deep hardening penetration, plus hard, wear-resistant surfaces. Send for additional information.

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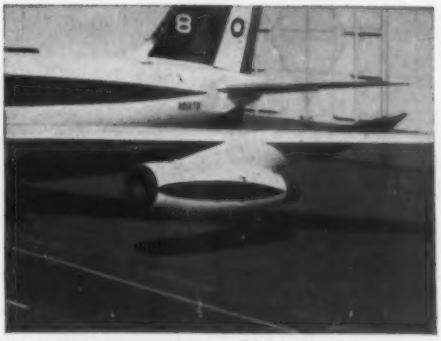

MAJOR 880 TITANIUM USES are (1) fixed outboard nacelle assembly—107.8 pounds per nacelle, 215.6 pounds per airplane; (2) lip assembly anti-icing nose cowl—53.8 pounds per nacelle, 215.2 pounds per airplane; and (3) right hand access door assembly—41.2 pounds per nacelle, 164.8 pounds per airplane. Republic supplies a major portion of the 870 pounds of titanium that goes into each Convair 880.

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(B-70) Welding Wire—Bulletin, 6 pp. Describes grades and applications. Gives chemical analyses, physical properties as welded for all grades and packaging information. Page Steel & Wire Div, American Chain & Cable Co, Inc, First & River Sts, Monessen, Pa.

(B-71) Stainless Steel Wire—Brochure, 12 pp. Includes stainless steel wire prices, chemical analyses of alloys, feet-per-pound table from 0.001 in. to 0.250 in. size tolerance table, table of standard production spools and coils, tensile strength ranges from 0.0018 in. to 0.034 in. and applications. Fort Wayne Metals, Inc, 3211 MacArthur Dr, Fort Wayne, Ind.

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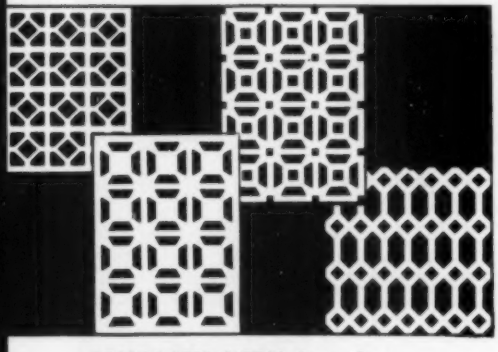

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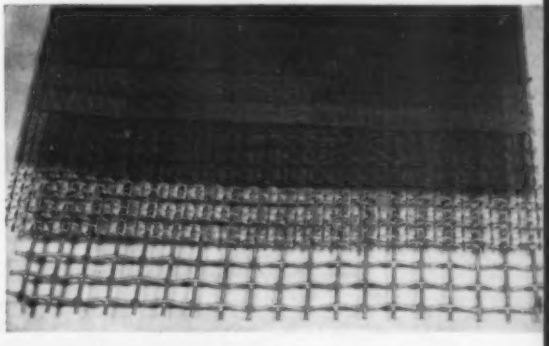

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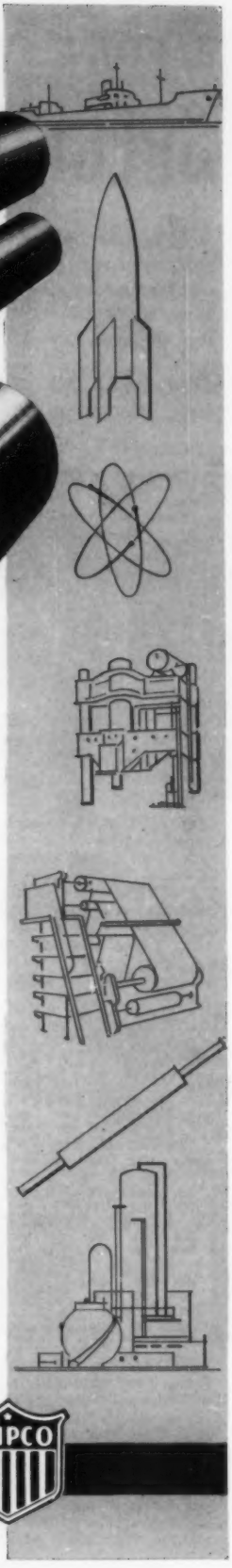

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4. **Electrolytic coatings of nickel are more uniform, assuring the necessary snug fit of all Jon-E's components. And the only finishing Aladdin needs on nickel-coated strip is a quick ball-burnishing.**

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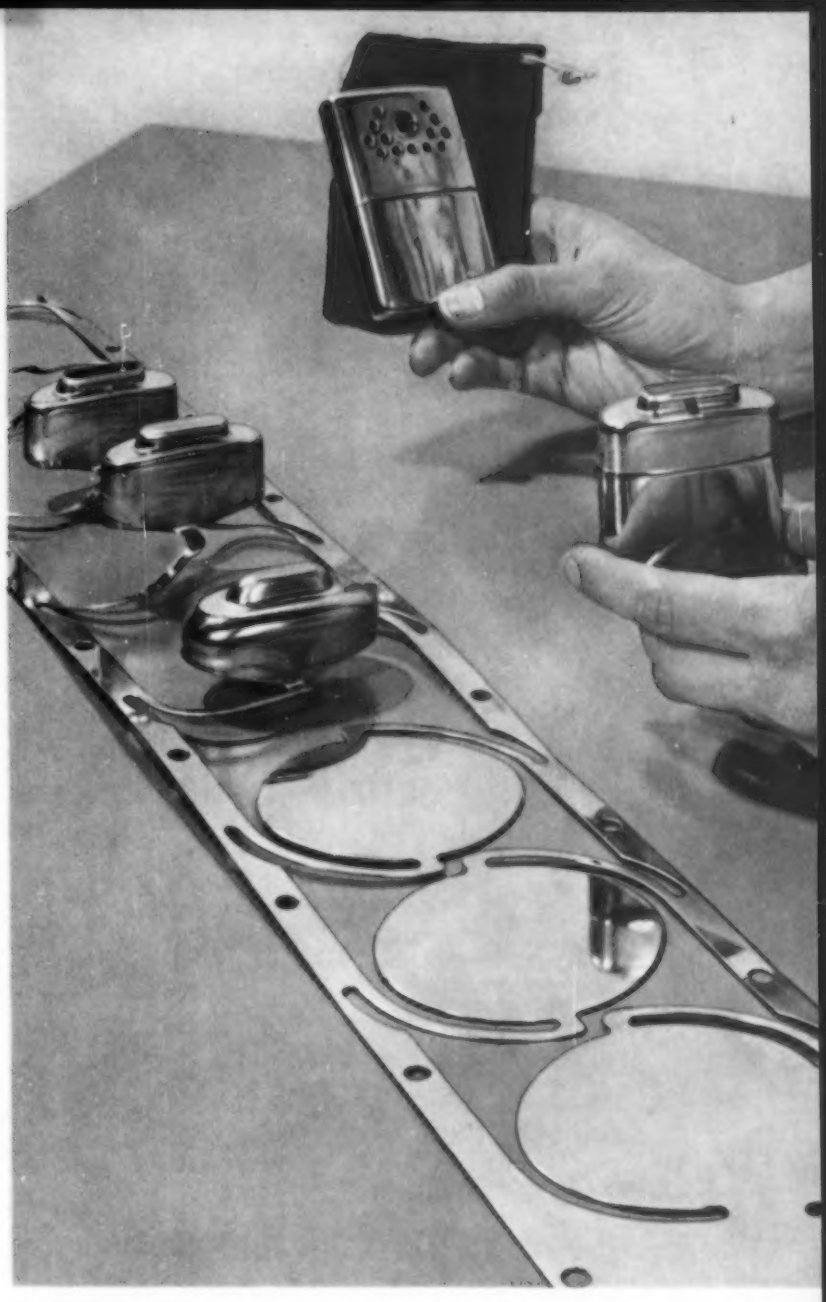

SIX-STAGE PROGRESSIVE die forms one Jon-E fuel chamber with every stroke of the press at Aladdin Manufacturing Company. This imposes severe demands on drawability of the 4½-inch nickel-coated steel strip supplied by Thomas Strip Division, Pittsburgh Steel Company. Aladdin credits Thomas Strip with 56% savings in metal costs, as well as sharply reduced scrap loss.

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HEAT NUMBER	ULTIMATE TENSILE STRENGTH psi	0.2% YIELD STRENGTH psi	PER CENT ELONGATION in 1"	PER CENT REDUCTION of AREA
Rx 36-57	194,400	168,000	13.5	40.8
Rx 36-58	202,400	170,400	12.5	28.0
Rx 36-59	192,800	160,400	12.0	39.0
Rx 36-60	198,000	162,400	13.5	40.0

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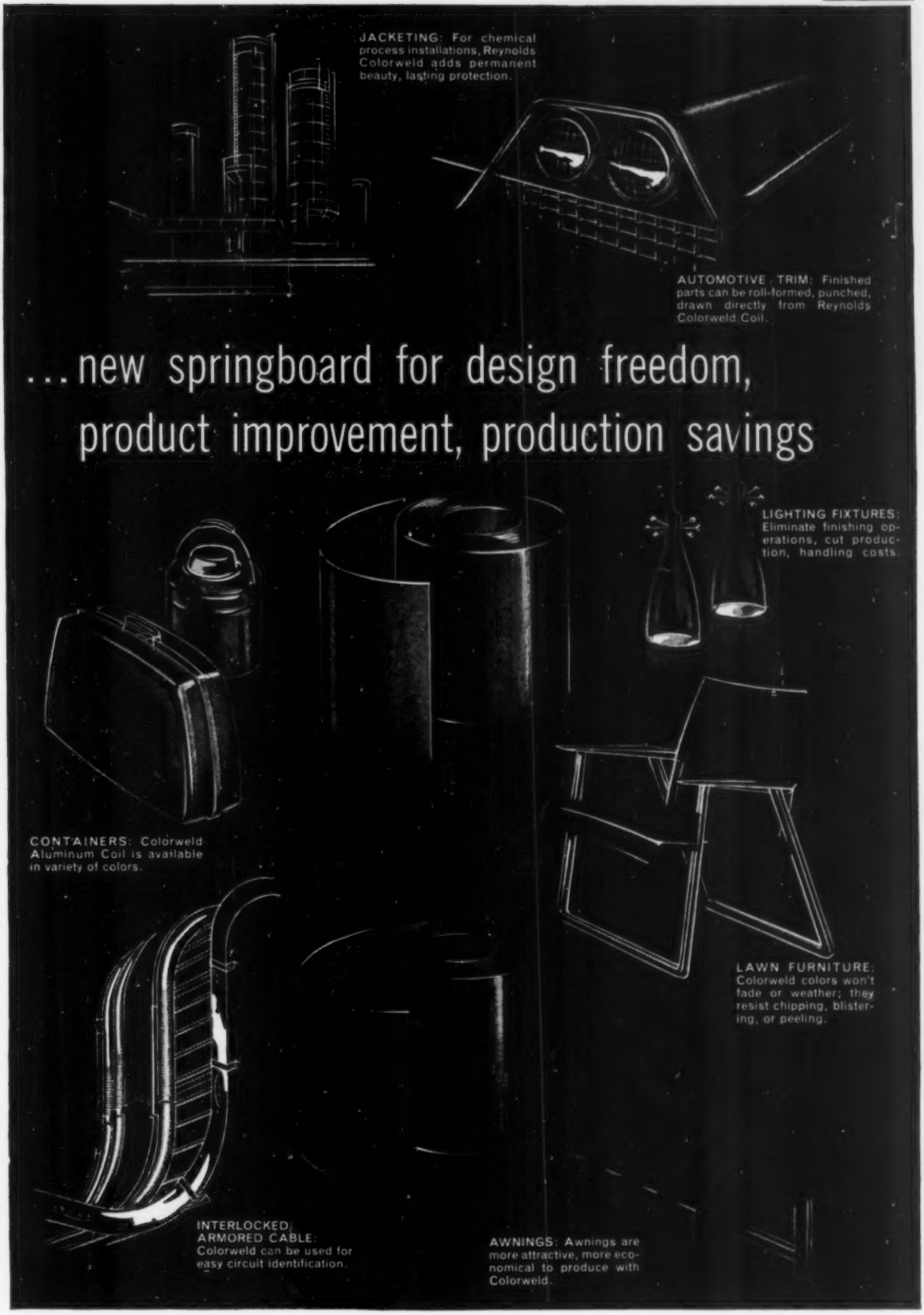
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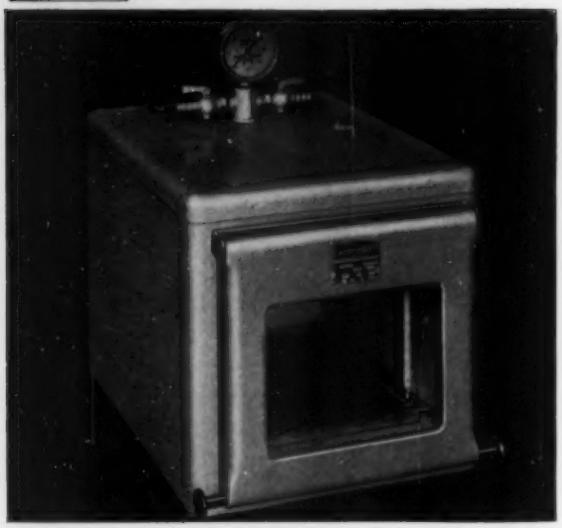
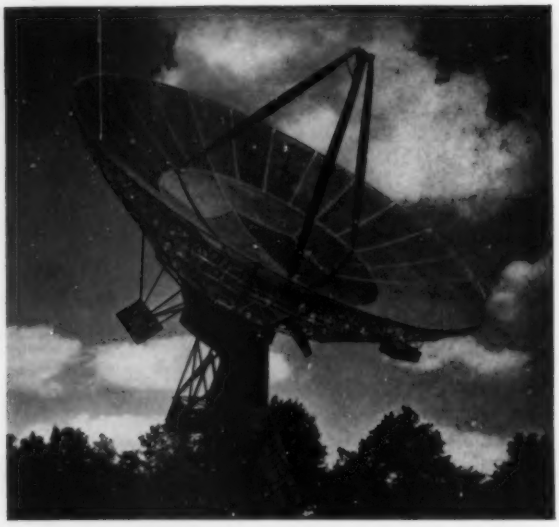
CONTAINERS: Colorweld Aluminum Coil is available in variety of colors.
LAWN FURNITURE: Colorweld colors won't fade or weather; they resist chipping, blistering, or peeling.
INTERLOCKED ARMORED CABLE: Colorweld can be used for easy circuit identification.
AWNINGS: Awnings are more attractive, more economical to produce with Colorweld.



CORROSION-RESISTANT SHELVING

Precision Scientific Company, manufacturers of laboratory ovens, puts corrosion resistance into shelving by making it from nickel-plated, Penmetal expanded metal. Shelving stays bright and clean through many years of service. It is strong, yet weighs next to nothing.

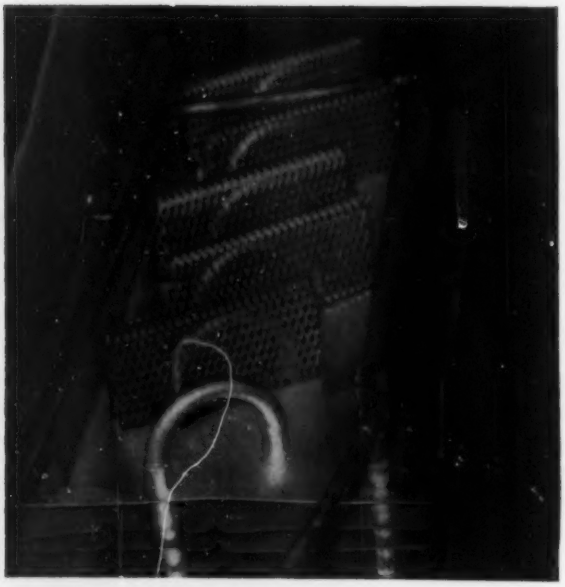


DURABLE ANTENNAE

D. S. Kennedy & Co., found Penmetal expanded aluminum the ideal material for the huge reflectors of their radio telescopes. Inherent structural strength helps prevent distortion with movement of the reflector... corrosion resistance provides 'round-the-clock weather protection.

3 PRODUCTS—3 ADVANTAGES

of Penmetal expanded metal



FUNCTIONAL COIL COVERS

Anheuser-Busch, Inc., St. Louis, uses Penmetal expanded aluminum in their freezing unit to cover exposed ends of evaporator coils. This provides extra prime surface for frost collection on the cooling coils and fins—increases efficiency of the units.

Here are three applications, typical of thousands in which Penmetal expanded metal has been used functionally to improve design. The wide range of valuable properties inherent in expanded metal makes it the ideal material for many, many jobs.

Up to 80% lighter than solid sheet of its own area, the diamond-truss pattern adds rigidity and strength. Gives free passage to heat, light, sound and air. Comes in carbon steel and corrosion-resistant metals.

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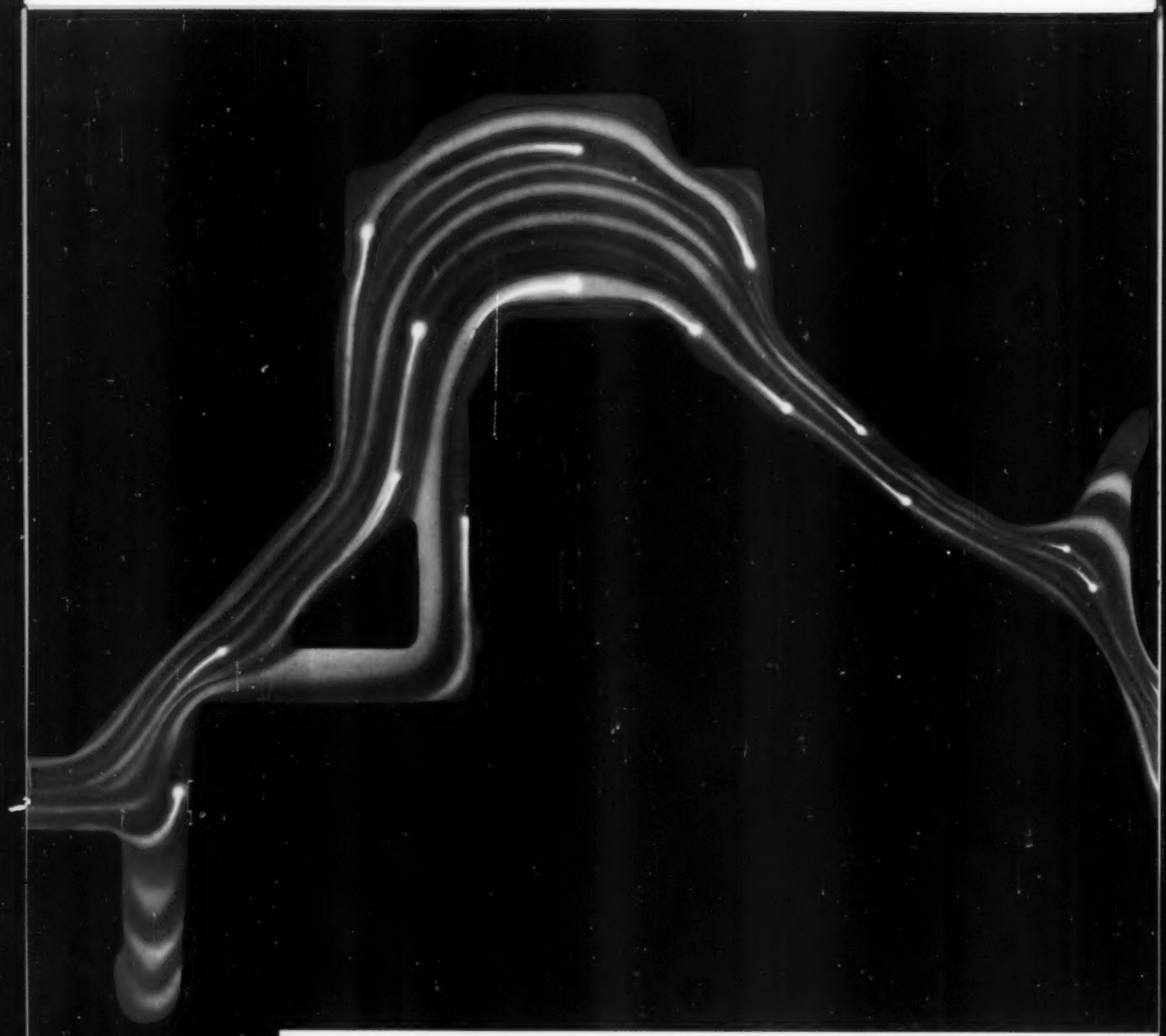

Fluid mapper pattern demonstrating liquid flow through a cross section of a Malleable differential carrier.

Versatility is Malleable

The ability to do most any job well is synonymous with Malleable iron castings. The variety of tasks they perform, from the commonplace to the spectacular, is legend. The strength and toughness . . . the freedom of design . . . the wide range of shapes and sizes . . . the excellent machinability . . . the economies achieved . . . all these advantages of Malleable combine to create an unexcelled reputation for versatility.

Whatever your needs, look first to Malleable.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

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MALLEABLE
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If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Versatility Is Key to Malleable's Increasing Use

Recent metallurgical advances have made the Malleable irons a family of metals uniquely capable of meeting the most diverse design, production and performance requirements. Whether the vital consideration is high strength, toughness, ductility, hardness, machinability, high or low temperature performance, wear resistance, or economy and adaptability for complicated designs, Malleable castings have the versatility to meet exacting specifications.

For versatility of shape, the casting process is unexcelled. It permits direct production of the most complicated components. The metal is placed exactly where it is needed regardless of the intricacy of the design.

The capabilities of the metal to be cast are of even greater significance, for every application has a different set of requirements. Here, Malleable iron provides unique opportunities to obtain better parts at less cost.

Holes can be punched in Malleable, surfaces can be coined to meet rigid specifications. The pearlitic Malleables can be surface-hardened for even better wear resistance. These and other advantages make today's Malleable iron one of the most versatile engineering materials available.

Although Malleable iron's properties are flexible, depending on service requirements, certain relationships remain constant. Malleable provides more strength and toughness per dollar than any other metal. It is also the most machinable of all ferrous metals of similar properties.

Malleable castings can be produced in sizes ranging from the hammer handle wedge, shown here, weighing less than an ounce, to the 1,125 pound bridge scupper. Throughout this range is an endless variety of castings, best made of Malleable for highest quality at lowest cost.

Shapes and sizes of Malleable castings are virtually limitless. The combination of Malleable's good castability with modern production techniques regularly results in sections as thin as 1/16" and tolerances of ±.005" per inch in sections of 1", with excellent surface finishes.

Engineering Aids Available

While the design of Malleable castings is not complicated, it will pay you to consult a skilled Malleable engineer who can offer time and cost saving suggestions for the production of better parts. As another aid to basic Malleable casting design, a special folder — *Data Unit 104 — Design Versatility* — is available from any member of the Malleable Castings Council and from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

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catalogs and bulletins.....continued

(B-72) **Wire Cloth**—Catalog, 64 pp. Describes and illustrates various weaves of wire cloth, selection and testing data, conversion factors and nominal characteristics before drawing and weaving. Reynolds Wire Div, National-Standard Co, Dixon, Ill.

(B-73) **High-temperature Wire**—Bulletin, 8 pp. Nickel-clad copper conductor insulated with a flexible vitreous enamel film which is firmly bonded to the conductor. Description, physical and mechanical properties, tables of sizes and characteristic graphs of high temperature wires. Hitemp Wires Inc, 1200 Shames Drive, Westbury, NY.

(B-74) **Perforated Metal**—Catalog, 48 pp. Illustrations of various cross patterns of perforated metal for ornamental applications. Cross Perforated Metal Plant, National-Standard Co, 166 Dundaff St, Carbondale, Pa.

(B-75) **Steel and Aluminum Materials**—Catalog, 240 pp. Lists and describes structural shapes of steel and aluminum. Also supplies industrial plastics and metal fabricating machinery. Also contains selection and buying data. Joseph T Ryerson & Son, Inc, Box 8000-A, Chicago 80, Ill.

(B-76) **High-strength Steels**—Brochure, 186 pp. Contains criteria for designing structures in the 50,000 psi yield strength range. Covers: proper unit working stresses; design of members for tension; compression; axially and eccentrically loaded columns; beam stress and others. United States Steel Corp, 525 William Penn Place, Pittsburgh 30, Pa.

(B-77) **Stainless Steels**—Brochure, 31 pp. Lists the more popular stainless steels, giving a description of the steel, some applications, and properties of concern to engineers and metallurgists. Sharon Steel Corp, Sharon, Pa.

(B-78) **Spring Wire**—Brochure, 4 pp. Describes advantages and uses; includes tensile strength tables for various grades of mechanical and upholstery spring wire. Page Steel & Wire Div, American Chain & Cable Co, Inc, First & River Sts, Monessen, Pa.

(B-79) **Tool Steels for Die Casting Process**—Brochure, 16 pp. Operating suggestions, recommended tool steels and heat treatent for each tooling application. Crucible Steel Co, of America, PO Box 2518, Pittsburgh 30, Pa.

(B-80) **Zinc Coating**—Brochure, 4 pp. Describes the operation, uses, costs and coverage of a rust preventative coating. Also presents testing and surface preparation data. The Sealube Co, 14 Valley St, Wakefield, Mass.

(B-81) **Zinc Die Castings**—Brochure, 64 pp. End uses, properties, compositions and limits of zinc alloys. Also contains photographs of applications. The New Jersey Zinc Co, 160 Front St, NY 38, NY.

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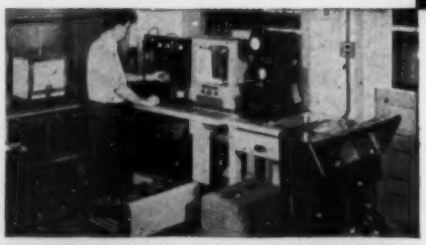

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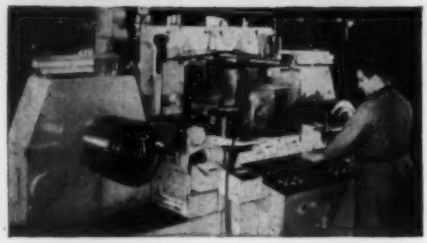

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(B-82) **Powdered Metal Parts**—Bulletin, 4 pp. Design considerations, production materials, and application information for powdered metal parts and self-lubricating bearings. Keystone Carbon Co, St Marys, Pa.

(B-83) **High-temperature Alloys**—Bulletin, 12 pp. Typical engineering properties data for cast nickel base high temperature alloys. Includes intended applications, chemical composition, heat treatment and other information. Misco Precision Casting Co, 112 Gibbs St, Whitehall, Mich.

(B-84) **Tool Steels for Forging**—Brochure, 16 pp. Includes heat treatment and recommended tool steels for various applications. Also operating suggestions. Crucible Steel Co of America, PO Box Box 2518, Pittsburgh 30, Pa.

(B-85) **Preplated Metals**—Catalog, 24 pp. Shows typical applications, fabrication techniques and contains table of properties. American Nickeloid Co, 2nd St, Peru, Ill.

(B-86) **Porcelain Electrical Products**—Bulletin, 8 pp. Description, dimensions and photographs of wire holders, brackets, knobs, tubes and other porcelain shapes for electrical applications. The Universal Clay Products Co, 1528 First St, PO Box 1631, Sandusky, Ohio.

(B-87) **Pearlitic Malleable Iron**—Brochure, 8 pp. Describes manufacture, chemical and physical properties, machinability; illustrated with micrographs. Industrial Div, National Malleable & Steel Castings Co, 10600 Quincy Ave, Cleveland 6, Ohio.

(B-88) **Aluminum Products**—Catalog, 36 pp. Describes the electrical, mechanical and chemical features of aluminum materials available in sheet, extruded, seamless drawn tube, heat and nonheat-treatable alloys, and other forms. Also covers fabrication practices and applications. Revere Copper and Brass, Inc., 230 Park Ave, NY, NY.

(B-89) **Wire Cloth**—Catalog, 96 pp. Gives dimenisons of open areas, weights and wire sizes. Includes open area formulas, conversion factors and ordering information. The C O Jelliff Mfg Corp, Pequot Rd, Southport, Conn.

(B-90) **Wire**—Brochure, 5 pp. Charts of wire gauge and footage, materials, electrical and mechanical properties of beryllium copper, nickel silver, aluminum, and others. Little Falls Alloys, Inc, 189 Caldwell Ave, Patterson, NJ.

(B-91) **Lead Products**—Bulletin, 8 pp. Quarterly publication describing lead installations in chemical, nuclear, plumbing, painting, ceramic, and other fields. Lead Industries Association, 60 E 42nd St, New York 17, NY.

(B-92) **Bronze Bearings, Bushings and Castings**—Brochure, 12 pp. Technical data on bronze materials. Listing of manufacturing facilities. The American Crucible Products Co, 1305 Oberlin Ave, Lorain, Ohio.

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MML	Heat-treated, molybdenum alloyed manganese steel... for castings requiring improved weldability, for extremely heavy metal sections, and castings exposed to excessive heating environments.	tensile strength ..... 120,000 psi yield strength ..... 52,000 psi elongation ..... 50% reduction of area 40%
MMH	Heat-treated, molybdenum alloyed manganese steel... for use in castings requiring optimum mechanical properties and wear resistance. Provides improved stiffness and resistance to peening and flow.	tensile strength ..... 120,000 psi yield strength ..... 65,000 psi elongation ..... 20% reduction of area 18%
CML	Heat-treated, air-hardening chrome-moly steel... for casting applications involving scouring or grinding wear. Suitable for more complex casting designs.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 10% reduction of area ..... 15% hardness ..... 275-375 BHN
CMH	Heat-treated, air-hardening chrome-moly steel... exhibits potentially improved wear resistance over CML (above), when shock loading is not sufficiently severe to cause breakage.	tensile strength ..... 155,000 psi yield strength ..... 130,000 psi elongation ..... 6% reduction of area ..... 7% hardness ..... 300-400 BHN
CS	Martensitic, multiple alloy steel with chromium, nickel and molybdenum... combines high mechanical strength with good abrasion and wear resistance.	tensile strength ..... 220,000 psi yield strength ..... 195,000 psi elongation ..... 8% reduction of area ..... 20% hardness ..... 300-500 BHN
HC	High chromium cast iron... provides outstanding abrasive wear resistance, where impact force is low but particle velocity and scouring forces are high.	tensile strength ..... 60,000 psi transverse strength ..... 7,000 lbs. deflection ..... 0.12 in. hardness ..... 400-600 BHN

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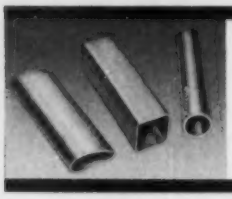

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catalogs and bulletins.....continued

(B-93) Aluminum-covered Steel Wire — Catalog, 12 pp. Describes electrical and mechanical properties; gives application data and suggested construction practices. Copperweld Steel Co, Wire & Cable Div, Glassport, Penna.

(B-94) Air and Vacuum Melted Alloys—Brochure, 15 pp. Describes air and vacuum melted nickel, iron and cobalt base alloys. Also, covers high temperature alloy available in sheet, bar, wire and foil forms. Cannon-Muskegon Corp, 2875 Lincoln Street, Muskegon, Mich.

(B-95) Steel Tubing—Catalog, 8 pp. Describes seamless and electric-resistance welded steel tubing in mechanical, airframe and pressing grades. Ohio Seamless Tube Div of Copperweld Steel Co, Shelby, Ohio.

(B-96) Aluminum Alloys and Mill Products—Brochure, 16 pp. Technical information on aluminum alloys, including properties, along with charts showing commercial sizes of aluminum mill products. Includes photos and description of facilities. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19, Pa.

(B-97) Nonferrous Products—Brochure, 20 pp. Lists chemical and physical properties of brass, bronze, copper and aluminum alloys and describes the machining, assembly and quality control facilities. Mueller Brass Co, 1925 Lapeer Ave, Port Huron, Mich.

(B-98) Stainless Steel — Bulletin, 4 pp. Gives chemical analysis, features and describes fabrication methods and applications. Republic Steel Corp, Republic Bldg, Cleveland 1, Ohio.

(B-99) Aluminum Wire—Catalog, 11 pp. Contains prices, product nomenclature and government specifications on round drawn aluminum wire. Alabama Wire Co, Florence, Ala.

(B-100) Briquettes — Brochure, 16 pp. Shows their effect on microstructure and machinability of gray iron. Also includes photomicrographs, data on cupola melting practice and heat and wear resistance. The Carborundum Co, Dept PE, PO Box 337, Niagara Falls, NY.

(B-101) Perforated Metals—Catalog, 32 pp. Instructions for ordering, diagramatic illustrations of standard perforations, materials, thicknesses and samples of industrial, architectural and ornamental applications. Diamond Mfg Co, PO Box 65, Wyoming, Pa.

(B-102) Seamless Metal Tubing—Catalog, 12 pp. Describes properties, characteristics and other technical information for various alloys and types of tubing. Discusses the annealing, finishing and testing of tubular materials. Precision Tube Company, Inc, Church Rd & Wissahickon Ave, North Wales, Pa.

(B-103) Chromium Metal—Bulletin, 4 pp. Gives typical analysis, photographs, test results. Chromalloy Corp, 450 Tarrytown Rd, White Plains, NY.

(B-104) Welded Stainless Steel Tubing and Pipe—Catalog, 48 pp. Describes the applications of stainless tubing and pipe; gives engineering information and specifications; analysis of metal grades; and physical, chemical and electrical properties. Trent Tube Co, Dept 165, 498 S Church St, East Troy, Wis.

(B-105) Nickel Silver and Phosphor Bronze Alloys—Catalog, 61 pp. Describes chemical composition, tensile strength and hardness values of typical alloys available in sheet, strip or coil form. Includes tables, drawings and tolerance data. Waterbury Rolling Mills Inc, Waterbury, Conn.

(B-106) Metal Specifications and Practices—Brochure, 16 pp. Contains graphs, photomicrographs and electromicrographs and lecture material presented to 1958 meeting of European Investment Casters Assn. Wai Met Alloys Co, 1999 Guoin St, Detroit 7, Mich.

(B-107) Zirconium—Brochure, 8 pp. Shows zirconium fabricated into parts such as thermowell, heat exchanger; values for use in chemical process systems to combat corrosion. The Carborundum Metals Co, Div, The Carborundum Co, Dept PE, PO Box 337, Niagara Falls, NY.

(B-108) Perforated Metal Sheets—Bulletin, 4 pp. Illustrations of patterns for acoustical ceilings, side walls and enclosures. Gives materials, mounting suggestions and applications. Also includes various selection criteria. Diamond Mfg Co PO Box 65, Wyoming, Pa.

catalogs and bulletins.....continued

(B-109) Carbon Graphite—Catalog, 12 pp. Describes physical properties, mechanical applications and suggested uses for line of carbon and graphite materials. Also lists impregnated varieties of these materials Pure Carbon Co, Inc, 441 Hall Ave, St. Marys, Pa.

(B-110) Copper Alloys—Catalog, 28 pp. Provides tables listing compositions, mechanical and physical properties and applicable ASTM specifications for copper and its alloy groups. Describes standard mill forms, manufacturing limitations and specially fabricated products. The American Brass Co, 414 Meadow St, Waterbury, Conn.

(B-111) Stainless Steel—Catalog, 50 pp. Shows architectural use of stainless steel for curtain walls, roofing and entrances. Includes sample set of specifications. Allegheny Ludlum Steel Corp, Oliver Bldg. Pittsburgh 22, Pa.

(B-112) Copper Alloys—Catalog, 48 pp. Covers materials, fabrication methods, chemical and physical properties and typical uses of coppers, brasses, bronze and nickel alloys. Revere Copper and Brass Inc, 230 Park Ave, NY, NY.

(B-113) Ceramic to Metal Terminals — Bulletin, 8 pp. Describes vacuum tight hermetic seal, bonding operation, application, and construction materials of standard and high voltage terminals. General Ceramics Corp, Crows Mill Rd, Keasbey, NJ.

If the question is perforating . . .

Ever stop and think that the answer to your design problem may be simple perforations? Whatever material you're working with, if it's metal, masonite, rubber, plastic, hard or insulated board for decorative or display usage, Hendrick can help you. Over a period of many, many years, Hendrick has built up the largest stock of dies commercially available.

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catalogs and bulletins.....continued

(B-114) Titanium Alloys—Bulletin, 24 pp. Covers the properties, fabrication, heat treatment and welding of various alloys. Tables, photographs, charts and graphs. Processing characteristics and applications are also given. Union Carbide Metals Co, 30 E 42nd St, NY 17, NY.

(B-115) Powdered Metal Structural Parts—Bulletin, 4 pp. Contains description of facilities and production capacities for powdered metal pole pieces, helical and spur gears, and others together with materials, tolerances and densities. Merriman Bros Inc, 185 Amory St, Boston 30, Mass.

(B-116) Beryllium Copper Products—Catalog, 19 pp. Facilities and services available relative to beryllium copper in spring applications. Includes property charts, tooling and heat treatment. Instrument Specialties Co, Inc, 244 Bergen Blvd, Little Falls, NJ.

(B-117) Metal Alloys and Products—Bulletin, 12 pp. Describes design advantages, characteristics and uses; includes physical properties and explains welding techniques. Ampco Metal, Inc, 1745 S 38th St, Milwaukee, Wisc.

(B-118) Flexible Stainless Steel Hose – Bulletin, 4 pp. Includes application, construction and specification data on close pitch corrugated stainless flexible hose; welded and brazed assemblies; ordering information. Atlantic Metal Hose Co, Inc, 308 Dyckman St, NY 34, NY.

(B-119) Phosnic Bronze—Brochure, 8 pp. Describes forms, tempers and properties of high temperature alloy; also, data on composition, fabrication procedures and typical uses. Chase Brass & Copper Co, Waterbury 20, Conn.

(B-120) Copper and Aluminum Tubing—Brochure, 14 pp. Describes facilities for seamless copper, copper alloy and aluminum tubing, and extruded aluminum shapes; quality control and design services. Wolverine Tube Div, Calumet & Hecla, Inc, 17200 Southfield Road, Allen Park, Mich.

(B-121) Chromium-nickel-manganese Stainless Steels—Bulletin, 6 pp. Composition, typical mechanical properties, fabrication, strength and corrosion rates of various stainless steels. Cost figures and typical products are included. Union Carbide Metals Co, 30 E 42nd St, NY 17, NY.

(B-122) Carbon-graphite Parts—Catalog, 7 pp. Describes manufacturing process, tolerances, finishes, physical properties and typical applications. Lists sales representatives. The United States Graphite Co, Div of The Wickes Corp, 1621 Holland Ave, Saginaw, Mich.

(B-123) Steel Tubular Products—Brochure, 40 pp. Dimensions, weights and specifications for continuous butt-weld and electric resistance weld steel pipe. Also, standard and tentative specifications for welded and seamless steel pipe. Bethlehem Steel Co, Bethlehem, Pa.

(B-124) Nonferrous Metal Products—Catalog, 20 pp. Lists physical, chemical and electrical properties of various bronze, brass, copper and aluminum forgings, alloys and special shapes. Includes charts, photographs and production data. Mueller Brass Co, Port Huron, Mich.

(B-125 Cold-rolled Strip Steel—Catalog, 16 pp. Shows gages, widths, tempers, finishes in prepainted, electrocoated or pattern rolled forms. Samples are inserted. Thomas Strip Div, Pittsburgh Steel Co, Grant Bldg, Pittsburg 30, Pa.

(B-126) Copper-nickel and Nickel-chromium Alloys—Catalog, 68 pp. Covers resistance alloys used as heating elements in furnaces, electrical equipment, and others. Resistance tables, design factors and standard specifications are included. Hoskins Mfg Co, 4445 Lawton Ave, Detroit 8, Mich.

(B-127) Powder Metallurgy Products—Bulletin, 7 pp. Describes development methods using copper, iron, tin, zinc and lead powders to achieve required properties and characteristics in the finished product. Gives bearing load charts, press fit values and assembly methods. The United States Graphite Co, Div of The Wickes Corp, 1621 Holland Ave, Saginaw, Mich.

(B-128) Honeycomb Structures—Brochure, 20 pp. Contains description of research facilities and current capabilities of high temperature all metal brazed honeycomb sandwiches. Includes brazing methods, list of nickel base brazing alloys, temperature ranges and application data. Solar Aircraft Co, 2200 Pacific Highway, San Diego, Calif.

(B-129) Phosphor Bronze—Catalog, 20 pp. Lists the properties, continuous casting procedure, applications, tempers, tensile strengths and specifications of various alloy forms. H K Porter Co, Inc, Riverside-Metal Alloy Div, Riverside, NJ.

(B-130) Stainless Steel and High Alloy Tubing—Catalog, 48 pp. Gives selection data for various types of tubing: pressure, aircraft, mechanical, heat resistant, and others. Also describes joining and installation methods. Tables, physical, chemical, electrical properties included. Crucible Steel Co. of America, PO Box 2518, Pittsburgh 30, Pa.

(B-131) High-temperature Metals—Brochure, 48 pp. Presents definitions and data on melting techniques, machining methods, selection and application of high temperature metals. Lists physical constants and chemical analysis of metals and alloys, temperature curves and charts. Universal-Cyclops Steel Corp, Bridgeville, Pa.

(B-132) Aluminized Wire—Brochure, 6 pp. Describes advantages of aluminum coated steel wire for such end use products as strands, fences, telephones, and others. Page Steel & Wire Div, American Chain & Cable Co, Inc, First & River St, Monessen, Pa.

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BYERS GUIDE

New Product Design Ideas from A. M. Byers Company VOL. 1 NO. 5

In Nuclear Equipment 4-D Does Not Distort Radiation Measurement

Manganese and carbon become excited or "stay alive" in a radioactive environment. 4-D Wrought Iron's *low* manganese and carbon content and *low* total metalloid content enable it to perform mechanical functions in nuclear processes without distorting radiation measurement. Check corresponding box in coupon for more information.

Corrosive Caustics Curbed By 4-D Wrought Iron

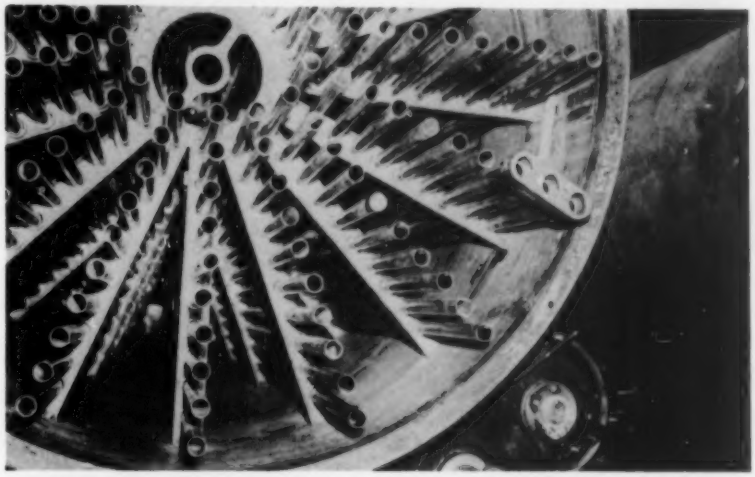
Two types of metal deterioration prevalent in caustic soda handling are effectively curbed by 4-D Wrought Iron. One is the intergranular type of stress corrosion known as caustic embrittlement. The other is the conventional loss-of-metal type of deterioration. Severity of attack depends on temperature and concentration.

Heated and/or concentrated caustic solutions become increasingly corrosive to most ferrous metals. It takes a silicate-based metal like 4-D Wrought Iron to combat this type of corrosion effectively. That's why design and maintenance engineers are turning to 4-D Wrought Iron pipe and plate for caustic soda heating tanks and heating piping used in caustic processes. Clip coupon for case history service reports.

Manganese Wrought Iron Resists Impact When Cold

A new specialty wrought iron has been developed for use as an economical, impact resistant metal for low temperature design.

You can use Mn Wrought Iron in the petroleum, chemical and refrigeration industries and others in which brittle failure is giving trouble. It's available in pipe, plate, other forms. Clip coupon for details.



Lafueille crystallizers, like the one pictured above in a sugar refinery, use cold drawn 4-D Wrought Iron tubing. 4-D Wrought Iron heat exchanger and condenser tubing is virtually unaffected by refrigeration gases such as ammonia, carbon dioxide and Freon. Highly resistant to both corrosion and abrasion, 4-D lasts longer than many higher priced ferrous and non-ferrous metals in salt water, heat transfer brines, and industrial cooling waters.

Comparisons Reveal 4-D Wrought Iron Tubing Will Give Lower Cost-per-Foot-per-Year

Industrial maintenance records indicate cold drawn 4-D Wrought Iron tubing displays more durability than expensive alloys and non-ferrous materials. Invariably, Wrought Iron gives longer tubing service life than carbon steel.

Here are two reports on typical industrial applications:

- A double-tube ammonia condenser in an ice plant had steel tubes. The cooling water used in this condenser contains 76 ppm of sodium chloride. The steel tubes failed after 2 years and were replaced by Wrought Iron tubes which are still in excellent condition after 18 years.
- Vaporizers for butane and propane gas production handle petroleum under pressure at ambient temperatures (10°F min.). Petroleum is vaporized by passing steam at 10 psi and 265°F through tubes inserted in the jacket. The unit operates continuously. In this application mild steel tubes were destroyed in 3 to 6 months and stainless steel tubes in 6 to 9 months. Wrought Iron tubes are serviceable for at least TWO years.

We have a technical report which covers briefly, but informatively, 15 similar heat transfer equipment installations. Actual names and places of the installations appear in this report. Comparative cost-per-foot-per-year figures have been calculated for Wrought Iron and Steel.

Check coupon for a copy of this convincing study.

A. M. Byers Company
Product Development Department
Clark Building, Pittsburgh 22, Pennsylvania

Please send data on items checked:

- ☐ Condenser and Heat Exchanger Tubing
- ☐ Nuclear Process Equipment
- ☐ Caustic Soda Handling
- ☐ Mn Wrought Iron
- ☐ PVC Pipe for Machine Tool Equipment
- ☐ Calorized Wrought Iron
- ☐ Laboratory Test Results
- ☐ Block Rock Construction

Name..... Title.....

Company.....

Address.....

BYERS GUIDE

New Product Design Ideas from A. M. Byers Company

Hex bar fits snugly in feed rack after liner is in place, so that no adhesive bonding agents are necessary.

New Design Idea* Muffles Noisy Machine Clatter

A new idea for muffling the clatter of machine tool equipment while in operation has been developed by A. M. Byers Company.

Recently a patent application* was made for the new idea which involves lining the bar guide or feed rack on automatic screw machines, turret lathes, etc. with PVC Pipe.

Noise is virtually eliminated and nicking or scratching of bar material is impossible. Some manufacturers have found that the metal feed rack can be replaced with PVC entirely on certain equipment such as engine lathes.

The original test installation of PVC Pipe in this application has been going strong for 10 months with no sign of trouble. And the cost of lining or replacing the feed rack with PVC Pipe is phenomenally low. It's less than $5.00 on single feed machines.

For more details on this one, check the coupon and mail to us.

*Patent pending, A. M. Byers Company

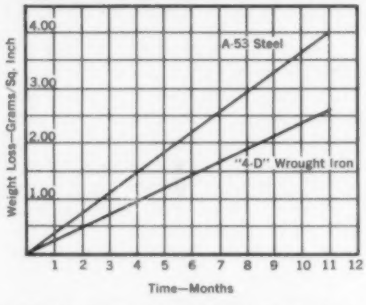
Soot-Blowers Use 4-D To Combat Oxidation

Blowing soot with steam or air tests the temper of the toughest metals. Oxidation is a constant threat, especially to fire tubes. Some metals flunk such hot-again, cool-again tests of endurance. But not 4-D Wrought Iron. 4-D can be furnished *calorized* to resist corrosion at high temperatures (1000—1600°F) prevalent in this service. Fill out coupon for more details.

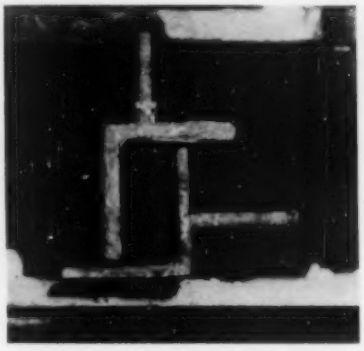
Lower Corrosion Rate For 4-D Wrought Iron

Data for 4-D Wrought Iron and steel plot as virtually straight lines, with 4-D Wrought Iron having a lower slope or rate of attack. Curves will flatten with time.

These data indicate that the 4-D Wrought Iron curve will continue to flatten at a lower rate than the steel curve. Other 4-D Wrought Iron test results are available on request. Please refer to coupon.



Here is a comparative laboratory analysis of corrosion losses in aerated salt water. Tests were conducted by A. M. Byers Company metallurgists.



This unretouched photo shows a comparison of 4-D Wrought Iron and steel after in-service testing at Mercier Brick Company, Dearborn, Michigan. That's 4-D Wrought Iron on top. Steel angle rests directly underneath. Both of these angles were ¼-inch thick when placed in service, side by side on the same rack.

Concrete Block Racks: Which Metal Lasts Longer?

If you guessed 4-D Wrought Iron over steel, you're 100% correct. After 11 months—101 cycles—the 4-D Wrought Iron angle has retained its original thickness. But the steel angle has already lost more than half of its original thickness due to extreme flaking and disintegration from corrosion. 4-D Wrought Iron's resistance to corrosive elements in block production processes is characterized by a hard, impregnable surface shield which cannot be flaked. Even with blows from a hammer. You be the judge. Which metal would *you* use in concrete block rack service? Send coupon for new booklet, "Modern Concrete Block Rack Construction."

For additional information on 4-D Wrought Iron, Contact Byers Division Offices in the cities listed below.

The maintenance and operating items appearing in BYERS GUIDE #5 were prepared by the Engineering Service Department of

A. M. BYERS COMPANY

Pittsburgh 22, Pennsylvania

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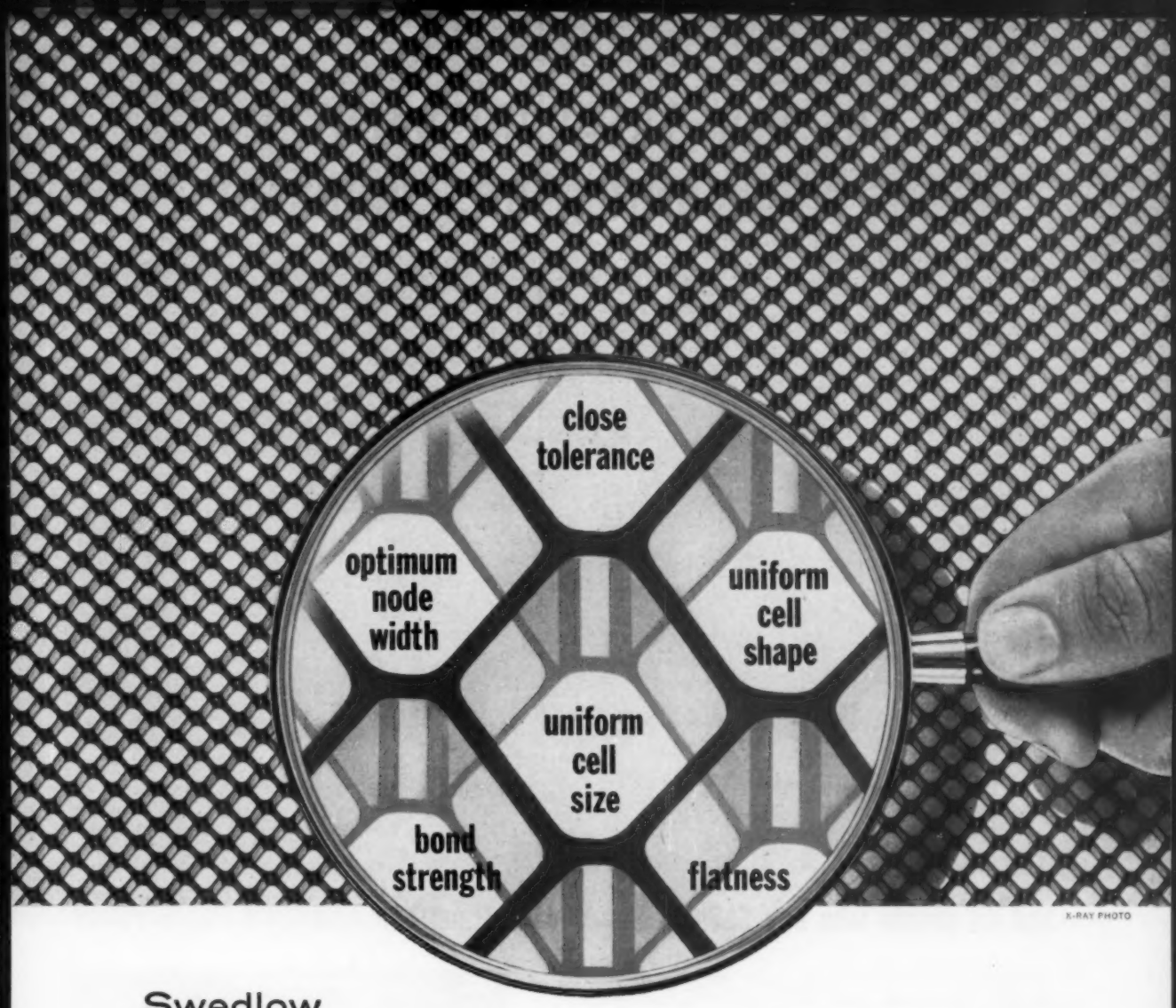
4-D Wrought Iron is immediately available and may be obtained through established distributors of Wrought Iron Pipe. Plate, bar, and other flat rolled products may be ordered direct.

Corrosion costs you more than Wrought Iron

Printed in U.S.A.



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PRECISION HIGH TEMPERATURE WELDED HONEYCOMB CORE

These are the all-important requirements for the manufacture of high temperature resistance welded honeycomb core.

Swedlow automatic manufacturing techniques are upgrading these industry standards. Close quality and process control assure you of the finest high temperature honeycomb core available.

Swedlow precision honeycomb core simplifies panel fabrication and assembly, eliminates rejections and the expense of replacement or rework.

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In the field of "super-alloys," Swedlow exploration is moving swiftly. We are investigating the fabrication of core from these and other materials using existing processes. Research and development programs have been established to evaluate other types of welding.

Swedlow is ready with a highly trained staff of engineers and technicians to assist you in applications of high temperature welded honeycomb core. Write today for full information.

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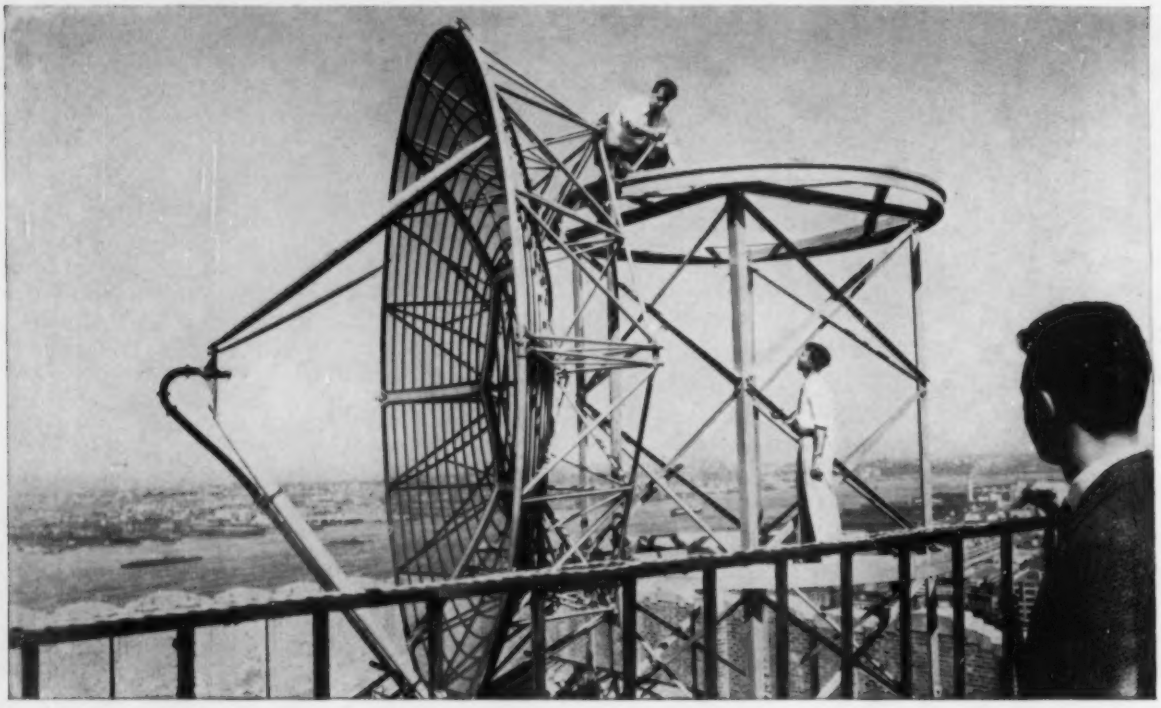
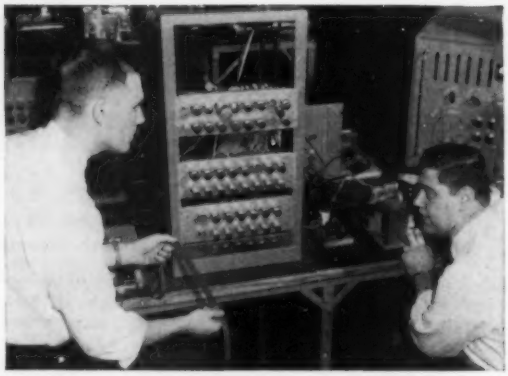


--and its people who buy Savings Bonds and strengthen America's Peace Power

The hundreds of thousands of Americans who earn their living at work with the telephone and telegraph industries are proud of the scope and skills of their service in local and worldwide communication. They're proud, too, of the vast and varied help their industry is giving to our national security.

Thousands of these telephone and telegraph people have a personal hand in building up America's Peace Power, too. They do this by purchasing U. S. Savings Bonds. Their regular purchase of Shares in America helps these patriotic people to reinforce their own security after retirement and to establish current reserves for such sound family projects as new homes and higher education.

It may be that your company has not recently shown your employees the advantages of buying bonds on the Payroll Savings Plan. If so, why not conduct a person-to-person canvass now? Contact your State Savings Bond Director for Payroll Savings promotion materials and personal assistance. Or write to the Savings Bond Division, U.S. Treasury Department, Washington 25, D. C.



Like so many thousands of their fellow craftsmen in the industry, these young employees are making regular use of their company's Payroll Savings Plan to contribute to America's Peace Power.

PRODUCT ENGINEERING

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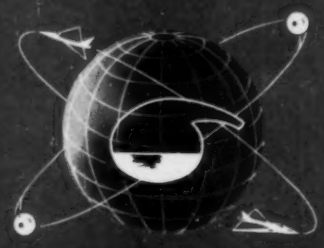
SECTION C

NONMETALLIC MATERIALS AND FINISHES



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How to Design for Better Plating 124

DESIGN ABSTRACTS

ELECTROPHORESIS FOR SPECIAL COATINGS

By applying electrophoretic deposition, metals, alloys, cermets, and solid lubricants can be bonded to virtually any metal with minute control of thickness, absolute uniformity, and low power consumption.

Special coatings to resist high-temperature oxidation, erosion and corrosion, as well as to obtain high-temperature lubrication, can now be applied to a wide variety of materials by utilizing the phenomena of electrophoresis and electro-osmosis. Developed industrially by Vitro Labs, the technique has been employed for applying molybdenum on steel, silicon carbide bonded with nickel on mild steel, molybdenum disilicide on graphite, nickel chromium on molybdenum, and molybdenum disulfide-copper on stainless.

How it works

Electrophoresis is the movement of charged colloidal particles in a liquid by application of an electrostatic field. If two electrodes are immersed in a prepared suspension and a potential applied to them, a deposition of the suspended material forms on one of the electrodes. The technique was employed a number of years ago in the production of rubber gloves and for depositing Alundum on electronic tube parts. Vitro, however, discovered that if a porous conducting body is placed between the electrodes, impregnation of the pores will take place, instead of deposition. This discovery has been developed into a special technique called electro-osmotic impregnation.

Although similar in theory to electroplating, electrophoresis and electro-osmosis are concerned with the motivation of charged particles. Electroplating deals only with surface charges.

"Electrophoresis—A new Coating Tool," Robert A Keeler and Louis C. Terminello, Vitro Laboratories; American Machinist, May 18, 1959, 330 W 42nd St, New York 36.

*

Polyester Premixes—Predicting Molding Characteristics

Molders and formulators of polyester premixes can now avail themselves of some long-needed convenient techniques for establishing quality standards and controlling the uniformity of their compounds with a degree of precision not possible heretofore. In addition, they can take useful shortcuts to evaluating the characteristics of new experimental compounds or troubleshooting unsatisfactory compounds with less dependence on costly trial moldings.

"How to Measure Uniformity and Predict Molding Characteristics of Polyester Premixes," Allan F Torres and Seymour S Fauer, Atlas Powder Co; Modern Plastics, Apr '59, 575 Madison Ave, New York 22.

*

Properties of Ceramics

The U.S. National Bureau of Standards at the request of the U. S. Army's Watertown Arsenal, evaluated the methods generally used to determine the mechanical properties of ceramics. The evaluation was needed because present uncertainty in such data is preventing the successful application of cermets in rockets and missiles.

"Mechanical Properties of Ceramics," Mechanical World, Feb '59, 31 King Street West, Manchester 3, England.

*

Extreme-pressure Greases

The current technology concerning extreme-pressure and high-temperature greases for the 65 to 400-F temperature range is reviewed. A series of additives which overcome the disadvantages of known extreme-pressure additives are discussed. Resistance to corrosion and decomposition at high temperatures was a major factor in the selection of the final additive system. Numerous greases with mean Hertz loads of 50 or greater have been produced, using various members of this additive system. Various homologous series can be shown to have unexpectedly beneficial results in comparison with other members of this series. The grease developed during this project is a blend of silicone fluids, a polyester fluid and an aryl substituted urea used as a thickener. This grease has been successfully tested as high as 400 F and as low as −90 F.

"Development of Extreme Pressure Greases," R K Smith, E F Houghton & Co.

For copies of this paper write NLGI, 4638 J C Nichols Pkwy, Kansas City 12, Mo.

*

Fluorester Lubricants

Some new lubricants prepared from highly fluorinated alcohols extend useful temperature limits for this type of material to 550 F, but they do not provide viscosity indices and low temperatures properties required in MIL-L-9236. Field evaluations of these new esters are still underway.

"New Fluorester Lubricants for High-temperature Applications," Ballard and Sommers, E I du Pont DeNemours & Co; SAE paper 9R.

*

Solid-film Lubricants for Over 1000 F

This discussion includes data developed in a literature search and includes some equations on the mechanism of wear and tables which give information on many of the solid films developed to date. Coefficient of friction for several metal-lubricant combinations are also included.

"High-temperature Solid-film Lubricants for Uses Above 1000 F," R E Crump, Electrofilm Inc; SAE paper 4S, 485 Lexington Ave, N. Y. 17.

*

Cadmium Plating Method

In some applications, it is desirable to plate 400 series stainless steels. The various types of stainless steel are similar to aluminum in that their surfaces are covered with a thin protective oxide film which is self-healing after being damaged. Owing to the passivity of this film, it is impossible to obtain an adherent electrodeposit

without a preliminary treatment that would remove the oxide film and prevent it from reforming before the application of the deposit. A satisfactory solution to this problem is to use a plating bath with a sufficiently strong acid concentration which would provide a secondary pickling effect.

"A New Economic Method of Treatment of Stainless Steels Prior to Cadmium Plating from Conventional Cyanide Solutions," Larissa Domnikov, Norair, A Div of Northrop Corp; Plating, May '59, 5800 N Marvine St, Philadelphia 41.

*

Analysis of Lubrication Deposits

Analytical techniques for separating and identifying components of a deposit are described. Several case histories indicating usefulness of such analysis in solving a number of lubrication problems are presented.

"Analaysis of Deposits," Lubrication, Jan 59; Texas Co, 135 E 42nd St, NY 17.

*

Hi-temp Properties of Reinforced Plastics

Five testing procedures for determining elevated-temperature design data are described. Evaluation procedures for determination of such phenomena as ablation at transient temperatures as high as 20,000 F.

"Critical Review of Methods for Determining Properties of Reinforced Plastics at Elevated Temperatures," Peterson and Schmidt, Wright Air Development Center; SPE paper 64, 65 Prospect St, Stamford, Conn.

*

Plastic vs Aluminum

Aluminum and plastics are often compatible, more often competitive. When used together the plastic sometimes serves one function and the aluminum another. Example: Electrical cables in which the plastic is an insulator, the aluminum a conductor. Or plastics can be laminated to aluminum and used together in a sandwich panel or as cabinets, etc.

When plastics strive to serve the same function as aluminum—or vice versa—they become direct competitors.

"Plastics Stalk Aluminum in Drive for Tonnage Markets," M J Schmidt, Modern Metals, Jan '59, 435 N Michigan Ave, Chicago 11.

*

Measuring Flammability of Plastics

Usefulness and limitations of various flammability tests are discussed, particularly those involving fire hazards.

"Critical Review of Methods for Measuring Flammability of Plastics," Sauber and Patten, Dow Chemical Co; SPE paper 63.

*

Plastics—Hardness, Abrasion, Wear Resistance

Equipment and techniques for hardness measurement and evaluation of abrasion and wear resistance are compared.

"Critical Review of Methods of Determining Hardness, Abrasion and Wear Resistance of Plastics," L Boor, Philadelphia Quartermaster Depot; SPE paper 61.

*

Reinforcement

Phenomena of fiber-resin laminate systems are discussed and compared with other reinforcement techniques. A discussion of fibers, adhesions and the characteristics of fiber-resin material failures is included.

"Reinforcement," Amidors and Goldfinger, Naugatuck Chemical, Div US Rubber Co; SPE paper 37.

*

Survey of New Plastics

Recently introduced materials of many types are briefly discussed, with comments on properties, applications and sources of supply. Included are boron compounds, polyorymethylene, Teflon-bonded ceramic fibers, glass microspheres, sintered nylon, perfluorocarbon, chlorinated polyether, polypropylene, polyethylene, diallyl phthalate, acrylics, polycarbonates, phenolics, reinforced plastics, silicones, epoxies, styrenes.

"New Materials—A Survey Paper," J H DuBois; SPI, 250 Park Ave, New York 17.

*

Developments and Trends in Gear Lubrication

As gear design has been modified to meet modern requirements, lubricants have likewise progressed, and in recent years this has been primarily accomplished by the use of additives to petroleum oils. These additives have provided a considerable increase in anti-wear and improved film formation between contacting surfaces.

It has been common knowledge for many years that both pressure and temperature greatly affect the viscosity of an oil. The relationship between temperature and viscosity is quite common knowledge and used extensively today. Considerable thought is being given by ASTM and other technical groups to a uniform method of measuring pressure-viscosity. With the increased loadings on gear teeth, the pressure-viscosity relationship becomes more important.

"Recent Developments and Trends in Industrial Gear Lubrication," E S Reynolds, Socony Mobil Oil Co Inc.

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Silicone Rubber for High-temperature Seals

Tests conducted at 350-450 F levels indicate compounds of 60-70 Durometer provide lowest compression set, but harder compounds are superior for high compressive stress requirements. Relative properties of compounds containing precipitated silica, fumed silica, diatomaceous silica filters, ditertiary butyl peroxide are also discussed. Max temperature of 500 F is indicated for all compounds.

"Properties of Silicone Rubber for High-temperature Static Seal," Todd and Miazga, Pratt and Whitney Div, United Aircraft Corp, SAE paper 50 V, 485 Lexington Ave, New York 17.

Comparison of RUBBER PROPERTIES

Physical properties can be varied by compcunding. Hardness, resilience, compressibility will be changed permitting different applications for the same rubber compound.

From: Stowe-Woodward Handbook

Rubber is interpreted to mean a great many molded materials. The many synthetic rubber polymers available, coupled with advances in compounding technology, make possible thousands of subtle variations in physical properties that allow countless new applications. Table I, for example, compares properties of the major types of rubber, actually, synthetic rubber manufacturers are constantly producing new polymers. Rubber molders are also compounding to extend the range.

SOME DESIGN PROPERTIES

Among the more important properties for design are hardness, resilience, and compressibility. Variations in compounds permit many physical changes for different applications.

Hardness. Rubber probably has a wider range of useful hardnesses than any other commonly used material. Table II shows Shore A Durometer values for some typical uses.

TABLE I—Comparison of Rubber Properties and Uses

	Natural Rubber	GR-S (Buna-S)	Neoprene	Nitrile Rubber (Buna-N)
Tensile Strength, max, lb	3500	3000	3000	3000
Elongation, max, %	800	500	500	500
Specific Gravity	0.93	0.94	1.25	1.00
Resilience	Excellent	Fair	Good	Fair
Abrasion Resistance	Excellent	*Excellent	Excellent	Excellent
Tear Resistance	Good	Good	Good	Fair
Flex Life	Excellent	Good	Excellent	Fair
Low Temp Flexibility, F	−70	*−80	*−70	−50
Heat Resistance, F	250	275	300	300
Compression Set Resistance	Good	Good	*Excellent	Good
Flame Resistance	Supports Combustion	Supports Combustion	Excellent	Poor
Electrical Insulation	Good	Good	Good	Poor
Corona Resistance	Fair	Fair	Excellent	Good
Ozone Resistance	*Fair	*Fair	*Excellent	Fair
Sunlight Resistance	*Fair	*Fair	Excellent	Fair
Weather Resistance	Good	Fair	Good	Fair
Permeability	Fair	Fair	Good	Excellent
Oil Resistance	Poor	Poor	Selective	Selective
Fuel Resistance	Poor	Poor	Selective	Selective
Water Resistance	Excellent	*Excellent	Good	Good
Chemical Resistance (dilute)	Good	Good	Good	Good
Solvent Resistance	Poor	Poor	Poor-Good	Good-Poor

* Requires special compound.

Data on this chart are to be considered as covering the normal working range. Values are affected by compounding required for specific applications. Always state specifically what oil, fuel and/or solvent resistance is required, as most compounds are selectively resistant.

The hardness range can be further extended by combining two different hardnesses or compounds in a single molded piece. Rubber parts can also be reinforced with fabric and metal inserts. The normal, practical, soft rubber working range is 15-90 Durometer. The maximum physical properties at any given hardness do not necessarily provide the best physical properties for any specific application. Usually, the best compound is one in which the physical properties have been balanced by the blending of compounding ingredients.

TABLE II—Typical Values for Some Products

Product	Shore A Durometer
Soft sponge rubber	5
Hollow floating toys	15
Rubber bands	35
Inner tubes	40–50
Automobile tire	60
Rubber heel	70
Hockey puck	80
Harness leather	90
Bowling ball	100

Arbitrarily taking 50-60 Durometer as the most common working range of soft rubber, mineral fillers are commonly used to obtain harder compounds; plasticizers to obtain softer compounds. While physical properties vary with hardness, the changes are related more directly to the compound ingredients introduced rather than to the change in hardness itself.

Resilience. This is the ability of an elastic material to recover its original size and shape after an applied force has been removed. Resilience is an outstanding characteristic of rubber. Its quick recovery makes it useable for compression springs, bumpers, and cushions.

Natural rubber is more resilient than synthetic rubbers and has a high ability to store energy. Resilience is affected by compounding since certain ingredients depress resilience by introducing internal friction. But, internal lubricants can be added that improve the resilience of the harder compounds.

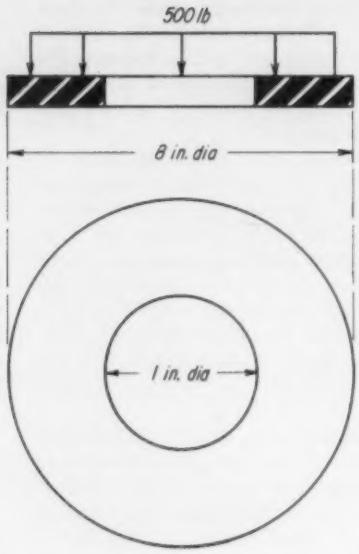
Generally, soft compounds around 30-35 Duro have maximum resilience, and hard compounds, about 90 Duro, have little resilience. Resilience is not uniform at any specific hardness but will vary with the type of compound, fillers, or plasticizers used, and temperature.

Temperature affects resilience in rubber much as it affects compressed gases. Lowering the temperature reduces resilience; increasing the temperature improves resilience. Butyl rubber shows more uniformity over a broad temperature range than other types. It has 80-100% better resilience at 212 F than it does at room temperature.

Compressibility. Molded rubber, when confined, has such great resistance to compression that it is often considered to be noncompressible. Regardless of distortion, for most application the volume is considered to be constant.

For practical purposes, rubber used as a compression pad or spring requires freedom of lateral movement to take advantage of resilience under

Acrylic Rubber	Butyl (GR-1)	Silicone Rubber	Polyurethane	Thiokol	Hypalon
3000	2500	1500	4500	1000	2500
300	700	500	600	400	400
	0.91	1.6	1.25	1.35	1.1
Fair	Poor (room) Good (200F)	Good	Good	Poor	Fair
Fair	Excellent	Poor	Excellent	Poor	Excellent
Fair	Excellent	Poor	Excellent	Fair	Fair
Good	Excellent	Fair	Excellent	Fair	Excellent
−30	−50	−100	−90	−40	−40
350	350	500	300	160	300
Good	Fair	Fair	Good	Poor	Fair
Poor	Poor	Good	Fair	Poor	Excellent
Fair	Good	Excellent	Fair	not used	Good
Good	Good	Excellent	Excellent	not used	Good
Excellent	Good	Excellent	Excellent	Good	Excellent
Good	Excellent	Good	Excellent	Good	Excellent
Good	Excellent	Good	Excellent	Fair	Excellent
Good	Excellent	Fair	Good	Good	Good
Excellent	Poor	Poor	Selective	Excellent	Fair
Excellent	Poor	Aromatic-Poor Non-arom-Good	Selective	Excellent	Poor
Fair	Excellent	Fair	Good	Fair	Excellent
Good	Very Good	Fair	Good	Poor	Good (oxidizing agents)
Excellent	*Good	Poor	Good-Poor	Good (Selective)	Poor



Example to determine load using Shape Factor

Area of 3 in. dia. disk	7.0686 sq in.
Minus area of 1 in. dia. hole	0.7854 sq in.
Load area	6.2833 sq in.
3 in. Circumference	9.4248 lin in.
1 in. Circumference	3.1416 lin in.
	12.5664
X Thickness ¼ in.	0.25
	628230
	251328
Free Area	3.141600 sq in.

$\frac{6.2833 \text{ (Load area)}}{3.1416 \text{ (Free area)}} = 2.0$ (Shape Factor)

$\frac{500 \text{ lb (Load)}}{6.28 \text{ (Load Area)}} = 80$ psi pressure on ring

30 Durometer good for continuous use at 127 psi.

TABLE III–Shape Factor, Compression Load Chart

Bold figures—Limit for continuous loading. Light figures—Limit for intermittent loading.

Shape Factor	30 Duro	40 Duro	50 Duro	60 Duro	70 Duro	80 Duro
0.2	**75 psi** 180	**100 psi** 210	**130 psi** 255	**145 psi** 260	**165 psi** 300	**200 psi** 340
0.4	**85** 200	**112** 230	**140** 285	**162** 290	**185** 345	**230** 400
0.6	**90** 220	**125** 265	**155** 320	**175** 330	**210** 395	**250** 460
0.8	**100** 240	**137** 290	**170** 350	**190** 370	**230** 445	**280** 530
1.0	**105** 260	**145** 325	**180** 387	**210** 415	**250** 505	**350** 595
1.2	**110** 275	**157** 350	**190** 420	**230** 455	**275** 560	**325** 670
1.4	**115** 290	**165** 375	**205** 455	**240** 500	**290** 610	**340** 725
1.6	**120** 305	**177** 420	**215** 480	**255** 540	**305** 660	**355** 785
1.8	**125** 318	**180** 440	**220** 510	**265** 580	**320** 705	**365** 835
2.0	**127** 325	**190** 475	**230** 527	**275** 615	**335** 750	**380** 885
2.5	**130** 345	**195** 490	**240** 590	**290** 690	**355** 840	
3.0	**135** 365	**200** 505	**250** 635	**310** 750	**370** 915	
3.5	**138** 380	**205** 530	**262** 670	**315** 790		
4.00	**140** 390	**210** 555	**270** 700	**320** 835		

compression. When used this way, resilience is a measure of rebound properties of the rubber.

Safe compressibility limits are about 40% for natural rubber compounds of 30 Durometer to about 20% for compounds at 80 Durometer. The load limits increase with hardness despite a reduction in compression ratio.

Compressibility is not only affected by the inherent hardness and stiffness of the compound, but, also, by the shape and thickness of the rubber piece itself. The useful compressibility range of a specific part can be closely approximated by determining the shape factor of the part.

Shape factor represents the ratio of one load face to the total area of the surface free to move laterally when the load is applied, Fig. 1. When the load faces are anchored as by bounding, the shape factor is a reliable guide to determining compressibility of a given hardness and load. Values in Table III are based on high quality compounds designed for use as bumpers, shock mounts, and other similar parts. Heavily loaded, low tensile compounds will have lower values than shown in the table.

When determining the shape factor, any lateral area which is restrained by an enclosure, either bonded or unbonded, must be deducted to calculate the free area. If the 3 in. round ring, Fig. 1, were molded and bonded into a metal recess for a depth of ¼ in., only the upper ¼ in. of the ring would be free to move outwardly. The free area would be reduced and the shape factor would be increased.

REFERENCE:
Molded Rubber Handbook published by Stowe-Woodward, Inc., Newton Upper Falls, Massachusetts. Price $2, 45 pp.

From: ASME Paper

Designing with Rigid Polyvinyl Chloride

Originally considered only for corrosion resistance, rigid polyvinyl chloride is now used as a structural material because of its good balance of properties, low cost and ease of machining.

M. BATIUK
J. A. ROLLS
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Two general types of rigid polyvinyl chloride are commercially available: Type I, or normal impact, has maximum chemical resistance; Type II, or high impact, is used where toughness is required. Table I shows the general physical characteristics.

Both types are based on unplasticized vinyl-chloride homopolymers and are similar except that a gain in impact for Type II is offset by a slight decrease in chemical resistance and service temperature. High impact PVC is widely used in profile extrusions as the better impact properties permit a minimum cross section.

SHORT-TERM PROPERTIES

The properties of the material are influenced by temperature because it is a thermoplastic. Hence, strength falls with temperature as shown in Fig. 1. For most comparisons the strength at room temperature is used; for specific applications, the temperature-use strength should be known.

A plot of tensile modulus vs temperature, Fig. 2, shows a similar decline; however, a plateau exists between −15 to 100 F. The rapid decline at 170 F indicates a second-order transition which changes polyvinyl chloride from a rigid material to a stiff, rubberlike material.

Any stressed application that goes above 170 F even for a short intermittent period will fail. This transition temperature is a basic property of the polymer; it has never been raised successfully by adding reinforcement or fillers.

However, it can be lowered sharply by plasticizers. Plasticizers will lower the service temperature and increase the creep rate even though room temperature properties appear to be the same.

Another temperature-dependent property is the impact strength. Table II shows the notched Izod impact values at various temperatures. Type II compound is affected by reduced temperature; however, the value at 32 F is still high enough for normal handling of the material.

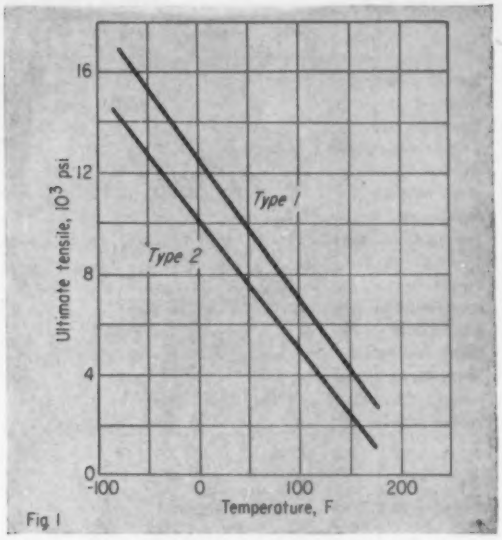

Fig. 1—Tensile strength vs temperature. Decrease in strength from over 10,000 psi at −40 F to less than 4000 psi at 160 F requires specific knowledge of the temperature-use range.

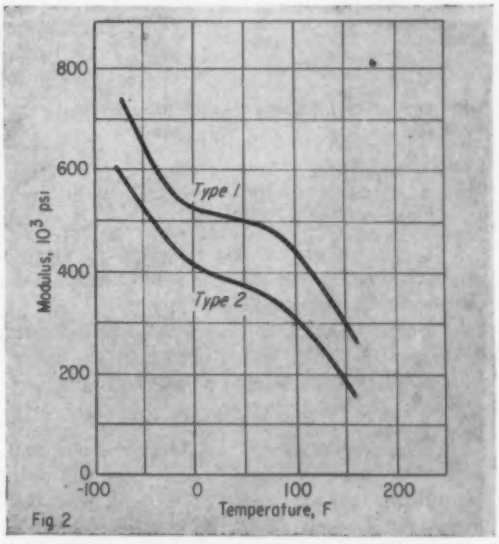

Fig. 2—Tensile modulus vs temperature. Rapid modulus drop is a second-order transition causing an outward change in the material form. Point is indicated roughly by the ASTM heat-distortion temperature.

LONG-TERM PROPERTIES

A limited amount of long-term creep data are available and some attempts are being made to extrapolate short-term data. Fig. 3 shows some available creep curves.

To allow for creep effect, it is possible to set the design stress at ½ the quick tensile strength of the compound at the application temperature. This value is probably conservative but should be used until long-term creep data are confirmed.

NONMETALLIC MATERIALS AND FINISHES

TABLE I—Physical Properties of Rigid Vinyl Plastics

	Type I	Type II	Units	ASTM Meths
Specific Gravity	1.38	1.35		D-792
Hardness	80	78	Durometer D	D-676
Tensile Strength	7,000	6,000	lb/sq in./78 F	D-638
Compressive Strength	9,600	8,600	lb/sq in./78 F	D-695
Flexural Modulus	14,500	11,500	lb/sq in./78 F	D-790
Elastic Modulus	425,000	325,000	lb/sq in./78 F	D-638
Izod Impact	0.8	15.0	ft/lb/in. notch	D-256
Thermal Conductivity	3.5	4.5	C.G.S. units $\times 10^{-4}$	
Thermal Expansion	2.8	5.5	Per F $\times 10^{-5}$	D-696
Specific Heat	0.25	0.25	Cal/G/C	
Heat Distortion	165	155	F at 264 psi	D-648
Burning Rate	Self Extinguishing	Self Extinguishing		
Dielectric Constant	3.7	3.9	1000 Cycles/30 C	D-150
Power Factor	2.8	3.9	1000 Cycles/30 C	D-150
Dielectric Strength	1400	1100	Volts/mil-20 mil sheet	D-149
Volume Resistivity	10^{15}	10^{15}	ohm/cm/78 F	D-275

TABLE II—Impact Values

	Type I	Type II
Temp, F	Ft-lb/in.	Ft-lb/in.
−40	0.32	0.33
32	0.32	1.56
78	0.87	17.7
140	1.4	16.4
180	5.2	18.7

TABLE III—Aging of Rigid Polyvinyl Chloride Plastic

	Type I		Type II	
	Tensile	Izod Impact	Tensile	Izod Impact
Original Properties	7000	0.60	5200	15.0
30 Days in Florida	7000	0.55	5400	15.0
4 Months in Florida	7400	0.65	5800	11.0
1 Year in Florida	7600	0.62	6500	10.0
19 Months in Florida	7500	0.76	5900	8.2
2 Years in Florida	7500	0.75	5600	7.0
3 Years in Florida	7400	0.65	6100	10.1
4 Years in Florida	7200	0.62	6000	7.2

A limited amount of data indicates the creep rate to be independent of variations in processing procedure but sensitive to compounding ingredients.

Long-term aging effects on tensile and impact properties are shown in Table III. Experience has indicated no definite limit on life because of outdoor exposure.

CHEMICAL RESISTANCE

Major advantage of rigid polyvinyl chloride is its wide range of corrosion resistance. It is generally resistant to nonoxidizing mineral acids, strong and weak bases, salt solutions and others. Table IV lists its chemical uses.

Rigid PVC does not suffer from electrolytic attack as it is a nonconductor but failure will sometimes occur as degradation. Usually failure is caused by a partial solution or plasticizing action which results in loss of strength.

THERMAL PROPERTIES

Material, compared with metals, has a high coefficient of expansion. Values for Type I and II are 2.8×10^{-5} and 5.5×10^{-5} in./in./F, respectively, as compared with a value of 1.3×10^{-5} for aluminum. Hence, when joining PVC pipe to metal pipe, flanges or compression-type fittings are used to allow for differential expansion. With long pipe lines, expansion loops or joints are best. In underground installations snaking of the lines is adequate to allow for expansion or contraction.

Coefficient of thermal conductivity for Type I is 3.5×10^{-4} (cal)(cm)/(sec)(sq cm)(C) compared with 0.53 (cal)(cm)/(sec)(sq cm)(C) for aluminum. Awareness of this low heat conductivity is leading to applications where this self-insulating property is being considered.

Another inherent property of rigid polyvinyl chloride is its nonflammability. Being a chlorinated polymer it will burn as long as a flame is held in contact but is self-extinguishing when the flame is removed.

FABRICATION TECHNIQUES

Normal plastic forming operations—vacuum forming, molding, calendering and extrusion—are used. In addition, many conventional machining operations can be performed effectively. Machining characteristics are similar to brass with the exception of a few precautions.

Heat is slow to dissipate because of the low thermal conductivity, and can cause softening and gouging by the tool and in extreme instances degradation of the stock. This can be prevented by using high tool speeds with small feeds, and adequate cooling. Rigid PVC requires better support than metal to prevent the work from bending away from the tool. Also, use sharp, smooth tools to avoid scratches and gouges. Sharp notches should be avoided in product design wherever possible.

Hot-air gun welding is used to fabricate intricate sys-

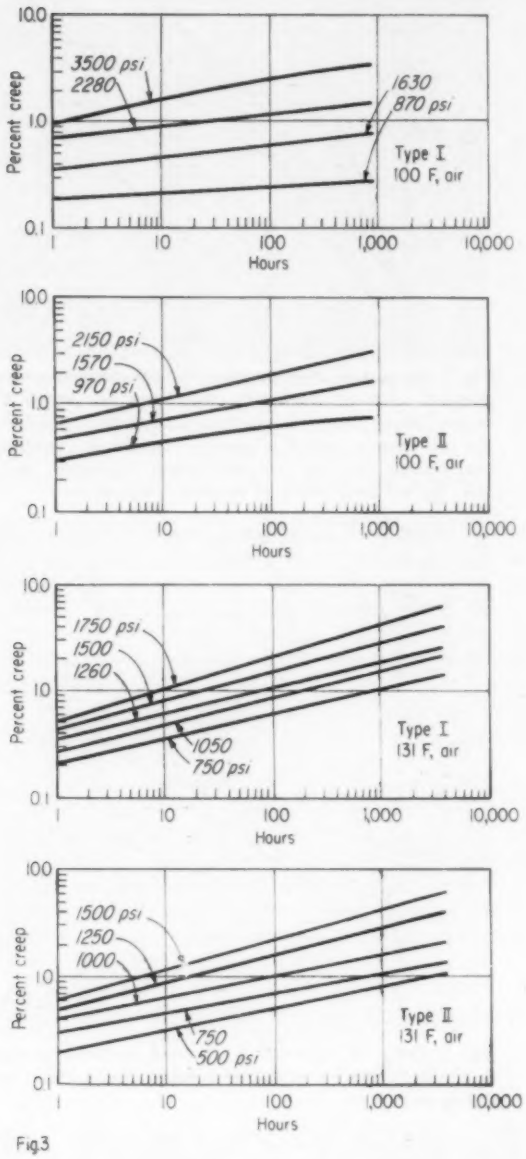

Fig. 3—Creep curves for the two types of rigid polyvinyl chloride under constant stress. Results are based on flat dumbbell samples loaded in tension. Research indicates environment is important in determining creep rate, but no data are presently available.

tems. This is similar to metal welding except hot air replaces the flame. Welding guns and welding rods are commercially available.

For piping systems requiring disassembly, regular threaded joints can be used on schedule 80, or heavier pipe. Regular pipe dies are used, but a plug insert may be necessary to keep the pipe from deforming away from the die. Teflon or lead-pipe dopes are used successfully but hardening or expanding pipe dopes should be avoided

TABLE IV—Chemical Resistance of Rigid Vinyl Plastics

	Concentration %	Type I 25 C	Type I 60 C	Type II 25 C	Type II 60 C
Acetic Acid	20	VG	VG	VG	VG
	80	VG	VG	VG	NR
	100	VG	NR	S	NR
Chromic Acid	10	VG	VG	VG	VG
	30	VG	VG	VG	VG
	40	VG	VG	VG	VG
Hydrochloric Acid	30	VG	VG	VG	VG
Nitric Acid	30	VG	VG	VG	VG
	60	VG	VG	VG	S
Phosphoric Acid	75	VG	VG	VG	VG
Sulfuric Acid	20	VG	VG	VG	VG
	50	VG	VG	VG	VG
	80	VG	VG	VG	S
Ammonia—Dry	100	VG	VG	VG	VG
Ammonia—Sol	28	VG	VG	VG	VG
Sodium Hydroxide	10	VG	VG	VG	VG
	50	VG	VG	VG	VG
Butyl Alcohol	100	VG	VG	VG	NR
Ethyl Alcohol	100	VG	VG	VG	NR
ASTM #1 Oil		VG	VG	VG	VG
ASTM #2 Oil		VG	VG	VG	VG
ASTM #3 Oil		VG	VG	VG	S
Benzene		NR	NR	NR	NR
Glycerin		VG	VG	VG	VG
Cottonseed Oil		VG	VG	VG	VG
Castor Oil		VG	VG	VG	VG
Linseed Oil		VG	VG	VG	VG
Barium Sulfide	Sat.	VG	VG	VG	VG
Ferric Chloride	Sat.	VG	VG	VG	VG
Sodium Dichromate	Sat.	VG	VG	VG	VG

VG—Very Good S—Slight Effect NR—Not Recommended

because of difficulty in breaking the joints for alterations. For the same reason, solvent-type cements should be avoided in threaded joints.

Solvent welding is preferred for permanent installations. A regular socket fitting without threads is used with a solvent cement. Solvent joints will gain 75% strength in 24 hr; full strength in three days.

PVC APPLICATIONS

Major use is for piping in the chemical industry, oil and gas fields and irrigation. These are areas where corrosion and contamination are serious problems with metal pipes.

A growing field is fabricated process equipment—tanks, tank linings, pump bodies, impellers, plating racks, ductwork, and filters. Here, chemical resistance, toughness, machinability, dimensional stability, and aging properties eliminate the need of protective coatings. An area of future growth is the field of architectural applications.

REFERENCE:

Designing with Rigid Polyvinyl Chloride by M. Batiuk and J. A. Rolls, Development Center, B. F. Goodrich Chemical Company, Avon Lake, Ohio. Presented at the 1958 ASME Semi-Annual Meeting, Detroit, Michigan. Paper No. 58-SA-67.

From: Aero/Space Engineering

Ceramic Materials

—PROPERTIES FOR STRUCTURAL USES

Elevated temperatures are making many of the structural materials impractical for certain parts of aircrafts, gas turbines and rocket engines. A solution is the use of ceramics. Examined are the properties of ceramics pertinent to their general use as structural elements.

W. J. KNAPP, Professor, Department of Engineering, F. R. STANLEY, Professor, University of California

New technological programs are producing environments in which the commonly used structural metals are subjected to detrimental conditions—elevated temperatures and corrosion. As a result, the possibilities of ceramics for structures is being more fully explored. A few of the many examples of new possible uses are certain areas of aircraft structures where considerable aerodynamic heating is developed and the high-temperature zones of gas-turbine and rocket engines.

Some of the obvious and desirable characteristics of ceramics for structural uses are: resistance to normal and high temperature corrosion; development of good surface finishes; and abundant supply of raw materials for manufacture. The following properties are of particular interest in connection with ceramic uses as structural materials.

DEFORMATION UNDER LOAD

In general, most solid crystalline materials exhibit both elastic and inelastic (plastic) deformations when subjected to loading. Ceramic materials are similar, but the extent of development of these deformations with changes in temperatures, stress, and time may be quite different from the results given by metals.

Deformation at room temperature under normal loading is essentially elastic up to the point of failure. For example, Fig. 1, shows the stress-strain relation for sintered magnesium oxide at room temperature (25 C). These results, and others for various ceramics, indicate purely elastic behavior for simple mechanical loadings. Table I gives values for the elastic modulus of several typical ceramic materials.

Deformation at elevated temperatures indicate that a marked inelastic deformation may occur. Fig. 1 shows the results of hydrostatically pressed magnesia (MgO) subjected to torsional loading at elevated temperature. Hysteresis loops for samples above 900 C are well defined, and the definite plasticity of crystalline MgO is clearly indicated by the defined hysteresis loops.

When crystalline ceramics are subjected to constant loading at elevated temperatures for extended time periods,

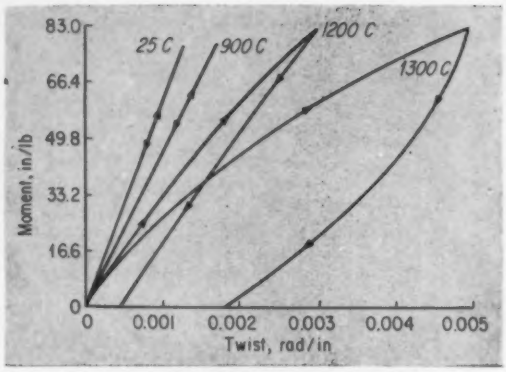

Fig. 1—Stress-strain characteristics for hydrostatically pressed magnesia ceramic. Market hyteresis loops are present for samples above 900 C. Similar behavior is shown by sintered alumina ceramics, and it is apparent that this is a common characteristic of most crystalline oxides. Ceramics, therefore, are not truly brittle at elevated temperatures.

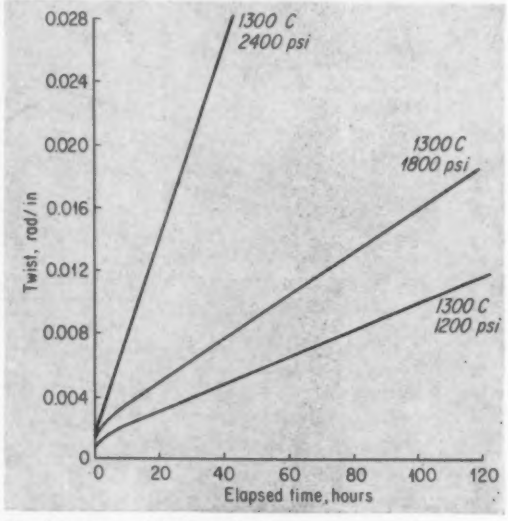

Fig. 2—Creep of hydrostatically pressed magnesia ceramic in torsion. Tests were run at constant temperature but various stress levels.

definite creep may develop; creep deformation is believed to be extremely small for normal loadings at room temperature. Fig. 2 shows the results of magnesia (MgO) under several stress levels at 1300 C. It was noted that a constant secondary creep rate is reached at constant stress when stress is not excessive. Length of time necessary for the creep rate to become constant diminished with increasing load and increasing temperature.

STRENGTH CHARACTERISTICS OF CERAMICS

Certainly the most significant characteristic here is the ability of most ceramics to support much larger loads in compression than in tension; in general, the compressive strengths of most ceramics are seven to 10 times greater than their respective tensile strengths.

Strength under static loading values can be found in Table I for several typical ceramics; note that tensile strengths range from a few hundred psi to about 40,000

Approximate Property Values[1] for Some Ceramics at Room Temperature

MATERIAL	YOUNG'S MODULUS OF ELASTICITY, PSI	TENSILE STRENGTH, PSI	COMPRESSI STRENGTH, SI	BULK SPECIFIC GRAVITY
Alumina (Sintered Al_2O_3)	54×10^6	38,000	425,000	3.96
Beryllia (BeO)	46×10^6	13,800	110,000	3.06
Brick, Building (Porous)	$1.5–4.0 \times 10^6$	250–1500	2000–12,000	1.9–2.6
Forsterite (Mg_2SiO_4)	12×10^6	10,000	85,000	2.8
Graphite (c)	2.8×10^6	10,000	43,500	2.52
Mullite Porcelain	15×10^6	13,000	100,000	2.5
Steatite Porcelain	14×10^6	10,000	100,000	2.6
Sewer Pipe, Hollow Building Block (Vitrified Clay)	$4–6 \times 10^6$	800–2000	8,000–15,000	2.2–2.6
Zircon Porcelain	25×10^6	15,000	120,000	3.7
Aluminum Alloy (Typical, for comparison)	10×10^6	80,000	60,000	2.76

(1) From a sampling of property values reported in the literature.

psi. Failure of ceramics under static mechanical loadings is almost always of a tensile type. It appears that the vulnerability of ceramics to failure in static loading is associated with the development of tensile stress.

Strength under dynamic loading is low since the lack of plasticity at room temperature increases susceptibility to failure by impact loads. This is particularly true if high localized stresses (stress risers) are present; failures resulting from such dynamic loadings also are typically tensile in nature.

Aluminum oxide specimens tested under cyclic loading at room temperature were found to have a fatigue survival stress (endurance limit) of about 0.57 of the single stroke bend strength. The fatigue survival strength of sintered alumina at temperatures up to 900 C was found to be similar to the room temperature value. Whitewear ceramic at room temperature had a fatigue survival stress of about 0.80 of the single stroke bend strength.

Research to date indicates that ceramics under cyclic loading at room temperature are not as greatly reduced in strength as many typical metal alloys.

DENSITY CHARACTERISTICS OF CERAMICS

The densities of most common ceramic materials are in the order of, or lower than that of aluminum. Table I gives some specific gravity values for some typical ceramics. The relatively low density enhances the value of ceramic materials as a primary material for lightweight structures.

PRESTRESSING OF CERAMICS

As previously noted, the outstanding limitation of ceramics for structural use is their inability to support large tensile loads.

Successful use of ceramics can be increased if tensile loadings can be nullified; a method of doing this is by compressive prestressing. The simple principles of prestressing, as applied to beams, are shown in Fig. 3; this may involve the use of wires or cables, loaded in tension, which produce a compressive stress in the material.

Preliminary studies indicate some success. A cantilevered ceramic beam, when prestressed, supported static loads about six times greater than those expected without prestressing. A roughly corresponding increase in resistance to failure by impact loading was also shown with the application of prestressing as well as a marked improvement in resistance to failure by thermal shock.

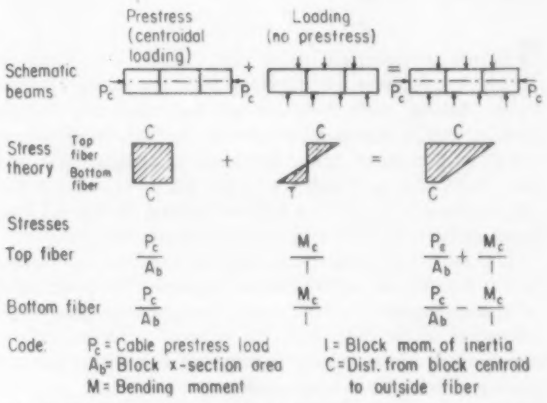

Fig. 3—Principle of prestressing a ceramic beam. Similar to concrete, this may involve wires or cables, loaded in tension, to produce a compressive stress in the ceramic material, thus increasing its load-carrying ability..

CONCLUSIONS

At room temperature crystalline ceramics undergo essentially elastic deformation only, while at high temperatures plasticity and creep may be evident. There is a reduction in brittleness at elevated temperatures.

The elastic constants and strength properties for various ceramics include a wide range of values. The compressive strength/density ratios are relatively high.

It appears that failures under static and dynamic loadings are chiefly tensile in character. Behavior seems to be closely related to the lack of plasticity of ceramics at room temperature.

REFERENCE:

Ceramic Materials—Properties for Structural Applications by W. J. Knapp and F. R. Shanley, Professors, Department of Engineering, University of California, Los Angeles, California. Published in *Aero/Space Engineering*, December 1958, p. 34.

From: SPI paper

High Temperature Behavior of Reinforced Plastics

Physical details of damage to reinforced plastics at 3000 to 23,400 F. Data are relevant to the prediction of the ability of the materials to survive when exposed to hot environments. This understanding may permit full utilization of available materials by designers.

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L. H. SHENKER
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Missile and Space Vehicle Department
General Electric Company

The use of materials which erode slowly—or ablate—are among the answers to extremely high temperature conditions. Among such materials are the reinforced organic plastics, which can sustain exposure to high temperatures for short periods of time. Applications ranging from the inlet ports of ramjet engines to the tail parts of solid fuel rockets have been cited, as well as thermal shields for long range ballistic missiles and rocket exhaust deflectors.

The attrition of reinforced plastics which occurs during severe heating is a complicated process. To understand what does happen, a detail study is necessary of the physical nature of the damage to the material produced by the exposure. A selected group of materials in environments of graded severity have been made.

LABORATORY EVALUATION METHODS

Selection of the test apparatus and the development of useful evaluation techniques for materials to be exposed to hot gaseous environments demand an understanding of the interaction between surfaces and hot gases. These interactions may be chemical, mechanical and thermal.

With respect to the thermal interactions, the heat flow to the body depends more on the enthalpy gradients existing in the gaseous boundary layer than on the temperature gradient. This is important to the proper correlation of test results because the enthalpy-temperature relations are markedly different for various gases. Thus, apparent contradictions in test data at a particular temperature can be generated if possible enthalpy differences are ignored.

There are several laboratory methods now in use for the ranking of materials with respect to their attrition rates in hot gases. These are: (1) hydrocarbon-oxygen flames such as are generated by rocket motors and torches; (2) cyanogen-oxygen flames, also generated by rocket motors and torches; and (3) arc plasmas of various compositions. Fig. 1 presents approximate temperature-enthalpy data.

MATERIALS TESTED

The phenolic resin used throughout performed well in other very high temperature tests. It is a laminating resin normally used for long service at 400-500 F.

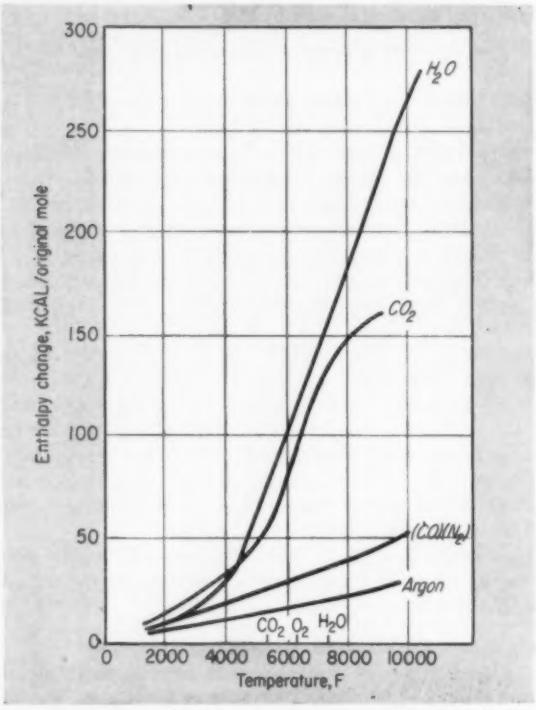


Fig. 1—Calculated enthalpy as a function of temperature for various gases. These data are approximate.

The reinforcements included a square weave nylon cloth, 181 Fiberglas cloth with a Volan A finish, and C-100-28 Refrasil cloth with a A-1100 finish. The resin was used as a prepreg on the cloth, and chopped for molding into ½ in. squares. Samples at various resin contents were prepared with each reinforcement.

RESULTS OF TESTS

Test specimens were weighed before and after testing, and results are reported as milligrams weight loss per kilowatt second of energy input at the electrodes. Net electrical input at the electrodes was 63kw and a majority of the tests were of a 10-second duration.

Phenolic-Refrasil specimens results are shown in Fig. 2. A crossover in relative performance occurs at 6300 F; at

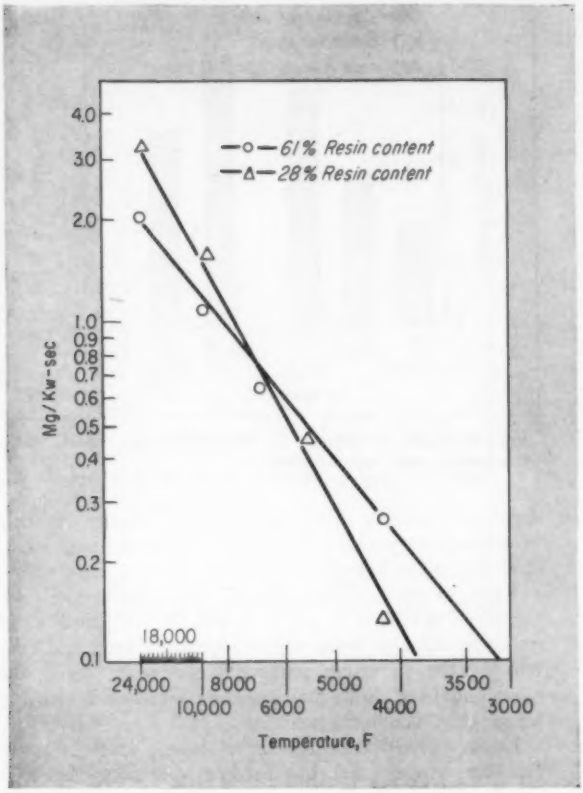


Fig. 2—Weight loss vs temperature for Phenolic-Refrasil.

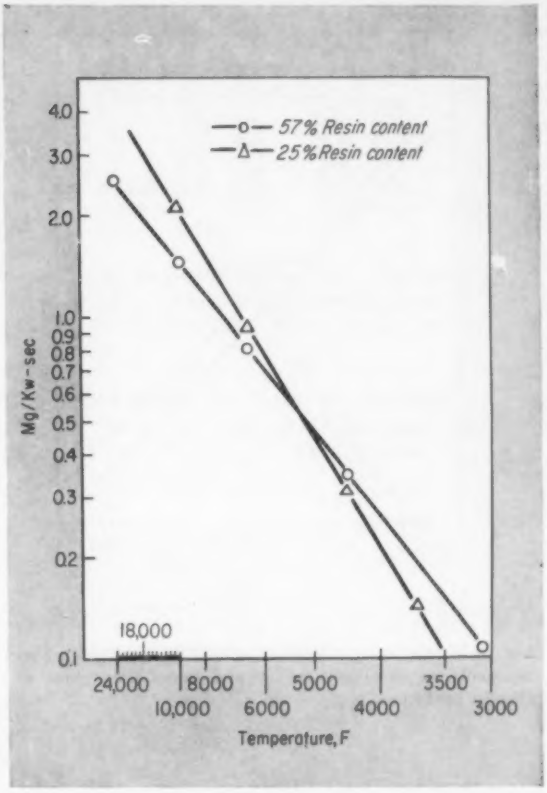


Fig. 3—Weight loss vs temperature for Phenolic-Fiberglas.

higher temperatures the high resin content material is superior, while at lower temperatures the reverse is true.

Phenolic-Fiberglas specimens, Fig. 3, show similar results. Crossover in relative performance is at approximately 5000 F.

Phenolic-Nylon, Fig. 4, which represents an all organic system shows little effect of changes in resin content.

Comparing the three materials, Fig. 5, indicated that nylon filled phenolics are distinctly superior to the inorganic filled materials at the highest temperatures. Crossover temperatures for the Fiberglas and Refrasil materials may correspond to points at which the inorganic materials are no longer fluid enough to be removed from the surface by the shear forces available in the plasma. The entire loss of material is then from the organic component.

These data confirm the superior performance or organic materials at very high temperatures, as well as the existence of crossovers in relative performance at particular lower temperatures. These crossovers pertain to the particular test apparatus and environment. In a supersonic environment, the rapid removal of molten material might shift the crossover temperature.

EXAMINATION OF SURFACES

Direct examination of the damaged surface under low magnification reveals relationships between composition, exposure conditions, and nature of the surface.

At the highest temperature, 23,400 F, the surface of the nylon reinforced material consists of a coke-like structure with a network of voids corresponding to the original nylon fibers. The lack of reinforcement in this char layer leads to the formation of fragile char caps which are periodically removed from the surface to leave it fairly clean. Under the same exposure, the surface of the two inorganic compositions are similar in appearance to sandblasted wood.

At a lower temperature, 10,300 F, the surface of the high resin content, inorganic reinforced materials continue to show a sandblasted surface effect. The lower resin content samples reveal a very close-grained surface, and the Fiberglas material even shows some cavities.

The appearance of the surface of the heated nylon reinforced specimens is relatively unchanged with variations in resin content and temperature. However, in the lower temperature samples, there are some highly reflective surface particles which may be graphitic.

As the temperature of exposure is reduced, more and more glassy material appears in the surface of the inorganic reinforced samples. At lower temperatures, the beads of glass appear larger and larger, possibly indicating viscosity changes. Finally, at temperatures below 4000 F, the fibers of Refrasil remain intact, showing no macroscopic damage and the material is considered stable.

CROSS-SECTIONAL EXAMINATION

Examination of cross-sections of all specimens indicates that thermal damage occurs in three distinct stages. (1) actual ablation, or removal of material from the surface. (2) A carbonized layer, with or without glass, and of various

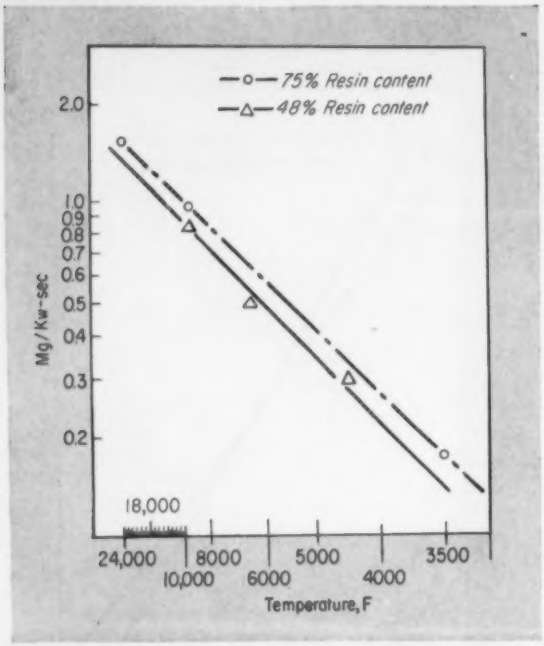


Fig. 4—Weight loss vs temperature for Phenolic-Nylon. This represents an all organic system and shows little effect of changes in resin content.

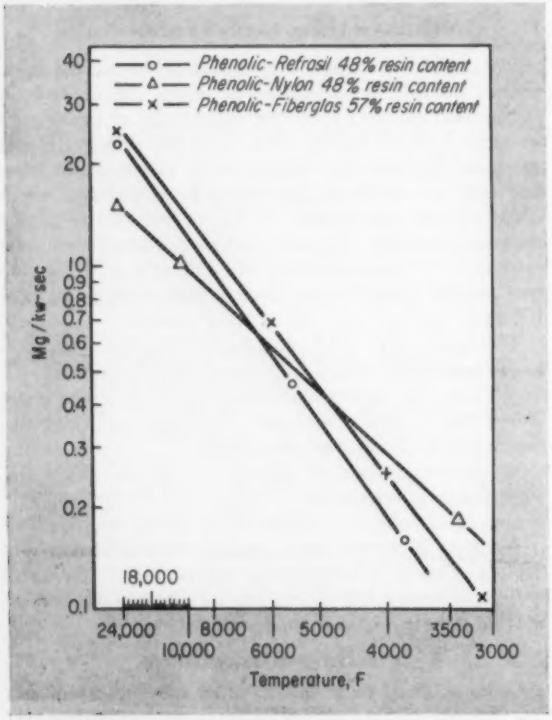


Fig. 5—Weight loss vs temperature for three compositions. Nylon is superior at high temperature.

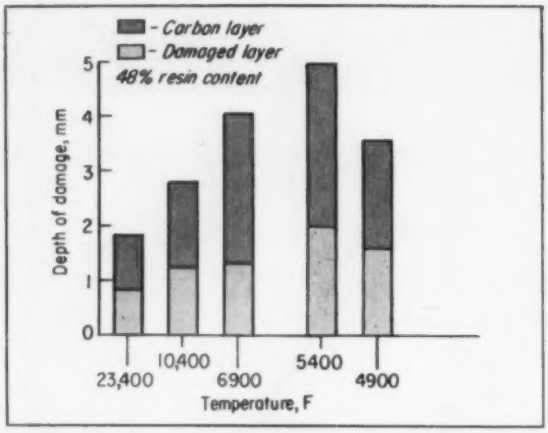


Fig. 6—Depth of damage in Phenolic-Refrasil varies with temperature and resin content.

degrees of porosity. (3) A discoloration, crazing, cracking or microscopic porosity of the layer behind the carbonized layer of the specimens.

Depth of the two damaged layers at various temperatures are shown in Figs. 6, 7, and 8. Depth of carbonization and secondary damage varies with temperature and resin content in the inorganic reinforced phenolics, while the organic material shows little variation over a wide range of temperature and resin content.

Depth of secondary damage is lowest at the highest exposure temperatures, but becomes greater as the temperature decreases. The depth of this damage is greatest for the inorganic reinforced materials. The thickness of the carbonized layer increases with decreasing temperature, reaching a maximum at 5400 F for Refrasil and Fiberglas reinforced material. Below this temperature the carbonization rate and secondary damage appear to drop off slightly in these 10-second experiments.

STEADY STATE

Relevant to the above discussion is the question of whether a steady state has been reached at the time of observation or measurement. Two methods were used for this determination.

In Fig. 9, gravimetric erosion data are presented for several materials exposed for varying lengths of time at 17,000 F. In all cases, the tests at this temperature indicated a steady state of damage from one second on.

It is reasonable to expect, however, that as the temperature and rate of heat input are decreased, the time to reach a steady state will increase. Theoretical consideration of the heat transfer process indicates that, ideally, for a given material, the product of erosion rate and total depth of damage should be a constant for all conditions where a steady state exists. On this basis, Fig. 10 indicates that steady state conditions existed for runs at all temperatures down to 8500 F. Below this temperature, either a steady state was not reached or the idealized theory was inappropriate for the experiments.

The fact that a steady state of erosion was generated in some of the experiments described here has implications which should be examined. In the absence of ablation,

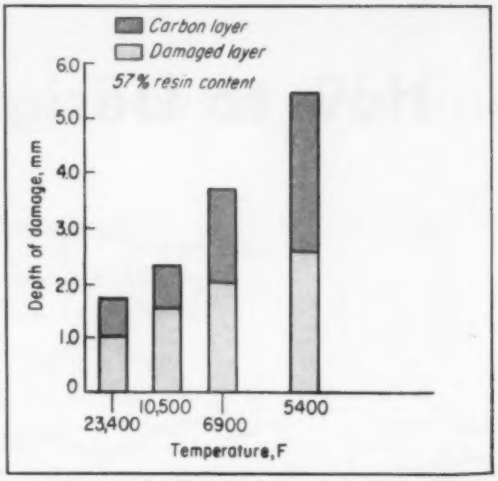


Fig. 7—Depth of damage in Phenolic-Fiberglas varies with temperature and resin content.

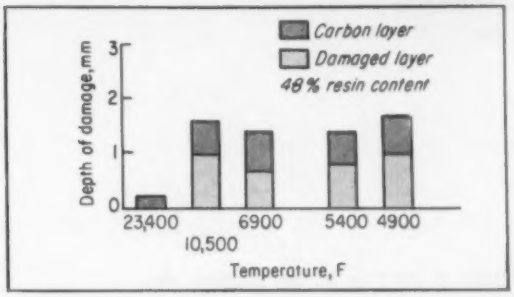


Fig. 8—Depth of damage in Phenolic-Nylon shows little variation over a wide range of temperature and resin content.

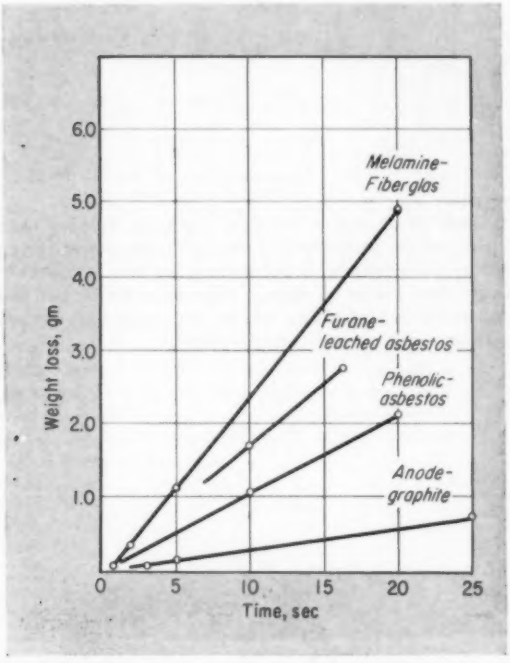


Fig. 9—Weight loss vs time for various plastic compositions at 17,000 F and shows a steady state of damage.

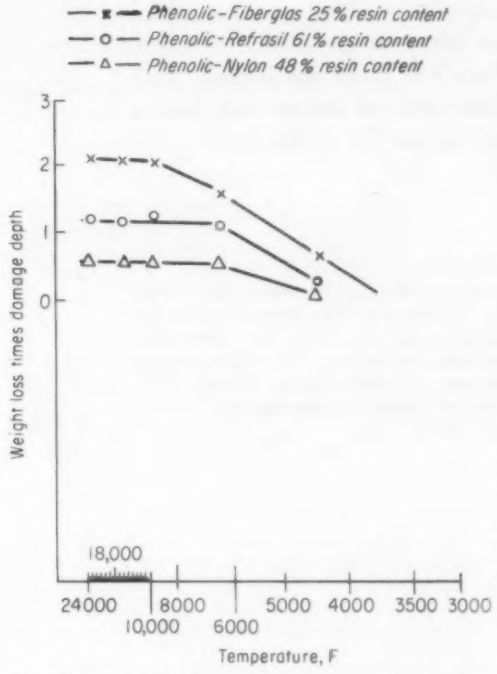


Fig. 10—Damage depth times erosion rate vs temperature.

when the surface of a slab of solid is exposed to a very hot gas, a time dependent temperature profile is generated. No steady state would be expected until, after very long times, the temperature of the slab becomes uniform. On the other hand, if the surface recedes—or ablates—at a uniform rate, it may tend to keep up with a particular profile and thus give rise to the observed steady state.

Furthermore, if a pyrolytic reaction such as carbonization takes place at a particular temperature, the depth of the carbonized layer will depend on the rate of ablation. The faster the ablation, the steeper the steady state temperature profile and the thinner the carbonized layer. The experiments confirm this, except when the heating rate is so low that the steady state is not achieved during exposure.

In these experiments two damaged zones are observed. First there is a carbonized layer, and beneath this a zone of uncarbonized but crazed material. If the crazing also occurs at a particular temperature, lower than that producing char, the thickness of the crazed layer will also depend on the steady state temperature profile. The crazed layer will then be thicker at lower ablation rates.

REFERENCE:

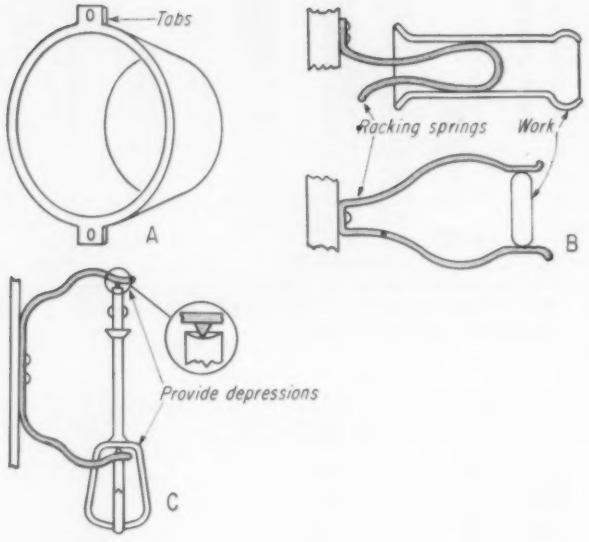
The Behavior of Reinforced Plastics at Very High Temperatures by I. J. Gruntfest, L. H. Shenker, V. N. Saffire, Missile and Space Vehicle Department, General Electric Company, Philadelphia, Pennsylvania. Presented at the 14th Annual Meeting of the Reinforced Plastics Division of the SPI, Chicago, Illinois.

From: INCO Bulletin

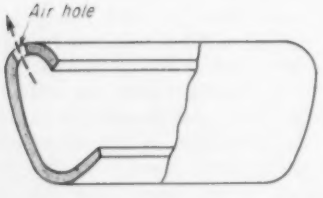
How to Design

When a part is to be plated, the design should consider the limitations of the plating equipment and the buildup of plating metal that may affect the final assembly. Given are some design points to watch. These will make the platers' work easier and will impart more beauty and longer life to the part.

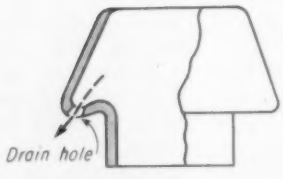
REFERENCE:
Answers to 40 Questions about Nickel Plating. Published by The International Nickel Company, Inc., New York. For Better Electroplating, by Peter C. Noy, Manufacturing Engineer, Canadian General Electric. Published in Product Engineering, June 23 and July 7, 1958.



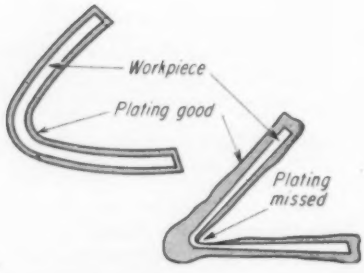
Mounting tabs . . .
. . . to facilitate attachment to the plating rack, A. Tabs are blanked with the part, and can be removed, if necessary, after plating. Part can be attached by spring pressure, B, but where it has been in contact with the workpiece there will be no plating. Depressions can be used in the part, C, where the lack of plating will be least noticed or least affect the part. Other special methods are also possible.



Air-relief hole . . .
. . . should be provided wherever an air trap is likely to occur. Plating would not be deposited inside part unless a hole allowed release of trapped air during submersion. Trapped air forms a buffer between plating solution and part. Only partial penetration of the buffer can occur.

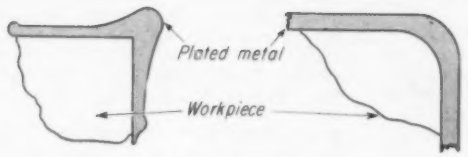


Drain hole . . .
. . . releases solution which would be trapped inside a part, causing solution "drag-out." Plating solutions are expensive and, in a well-regulated bath, the drag-out losses are often the highest cost item. Without drain hole, undrained solution would be washed away by rinses.

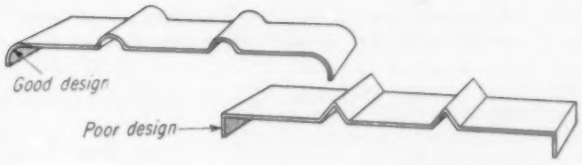


Inside-corner radii . . .
. . . should be as large as possible. In theory, plate cannot be deposited where an inside corner is less than 90°. Plating thickness at such corners is vastly improved by large radii. If radii are less than ¼ in., auxiliary anodes may be necessary to achieve sufficient plate thickness.

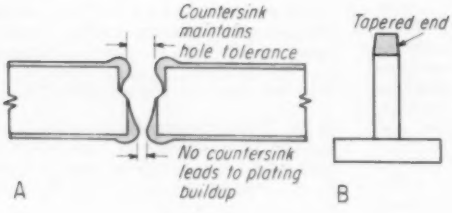
for Better Plating



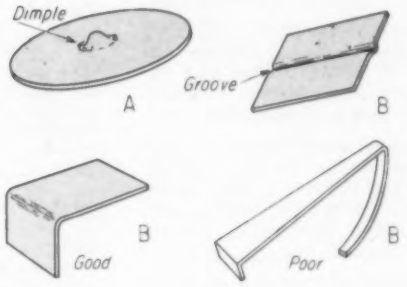
Outside-corner radii . . .
. . . should also be large. Nickel builds up on prominences because current tends to be greater there. Cathodic finger may be required on plate rack to distribute current density for even plating over the workpiece.



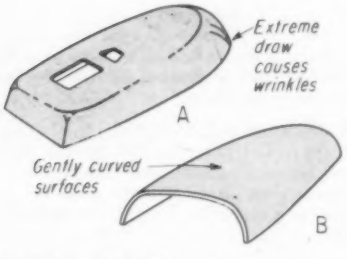
Ridges and grooves . . .
. . . should be rounded as much as possible. Plating build-up on sharp ridges, if abnormally thick, causes greater stress and often increases brittleness. Combined with later buffing wheel pressure, condition can weaken plate.



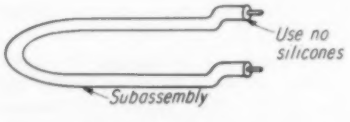
Adequate hole tolerance . . .
. . . is necessary to prevent buildup on hole edges that reduces effective diameter. Countersink, A, to keep hole fully open. Deep in the hole, plating will be deposited either very thinly or not at all. Studs, B, for similar reasons, should have a tapered entry; otherwise, excessive tolerances may be necessary.



Small flat parts . . .
. . . that will be barrel plated should be grooved or dimpled, A. This prevents them from clinging together and blanking one another from the plating solution. Small parts, B, should also be stable enough to withstand the vigorous tumbling action of barrel plating without distortion. Avoid light gage, narrow parts, where possible.



Draws on presswork . . .
. . . should be as gentle as possible. Extreme draws, A, often cause wrinkles. When polished out, the crystalline center of the metal, instead of the wrought surface, is bared to the plating solution. Gently curved surfaces, B, are easier to buff and polish than flat surfaces.



Compatibility with plating solution . . .
. . . is essential for materials used on plated subassemblies. Silicones, for example, will kill all foams purposely produced in cleaning and plating solutions; rubber gaskets will dissolve or thicken; aluminum dissolves. Planning is important in selection of materials to be plated.

Deeply recessed parts . . .
. . . require auxiliary anodes to get chrome plate into recess. Nickel is better, but real corrosion resistance may require special processes or designs to get complete plating. The problem: chrome plate will not "throw" in recesses unless auxiliary anodes are used.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(C-1) **Plastic Molding Compounds**—Catalog, 50 pp. Data sheets giving properties of phenolic and melamine reinforced molding compounds before and after molding. Includes suggested molding conditions, price schedule, description of specialized services offered. The Fiberite Corp, 512-528 W Fourth St, Winona, Minn.

(C-2) **Felt Products Design Book**—Brochure, 24 pp. Technical and application information on felt as a design material. Includes properties, special data on felt for seals, lubrication, filtering, vibration absorption, polishing, and insulating. The Felters Co, 210 South St, Boston 11, Mass.

(C-3) **Silicone Rubber Tape**—Bulletin, 4 pp. Description of physical properties and applications of silicone rubber tape for electrical assemblies. Moxness Products, Inc, 1914 Indiana St, Racine, Wis.

(C-4) **Mechanical Rubber Goods**—Catalog, 12 pp. Depicts plant facilities, types of products, latest ASTM and SAE, rubber designations and ordering information. Williams-Bowman Rubber Co, 1941 S 54th Ave, Cicero 50, Ill.

(C-5) **Glass-reinforced Plastics**—Brochure, 4 pp. Outlines structural, weight, decorative, and other advantages of reinforced plastics. Describes facilities and experience for molding wide range of quality fiberglass products in volume from matched metal molds; illustrations of facilities and products. Structurlite Plastics Corp, Dept PE 59, Hebron, Ohio.

(C-6) **Glass**—Bulletin, 12 pp. Properties, design data and basic forms of various types of glass. Corning Glass Works, Corning, NY.

(C-7) **Rubber Coated Fabrics**—Catalog, 7 pp. Lists physical characteristics, engineering and ordering information with suggested end uses of natural and synthetic rubber coated fabrics. Describes design and fabrication services. Vulcan Rubber Products Div, Reeves Brothers, Inc, 1071 Ave of the Americas, NY 18, NY.

(C-8) **Industrial Crepe Papers**—Brochure, 4 pp. Describes properties of the product for electrical and non-electrical uses. Includes data sheets. Dennison Mfg Co, 300 Howard St, Framingham, Mass.

(C-9) **FEP-fluorescent Resins**—Bulletin, 8 pp. Describes processing technique, electrical, mechanical and chemical properties, performance tests and military specification numbers. Charts, tables and photographs of typical applications. E I du Pont de Nemours & Co, Inc, Wilmington 98, Del.

(C-10) **Butyl Rubber**—Catalog, 12 pp. Applications of butyl rubber. Comparison graphs which show effect of weathering and sunlight heat aging, electrical stability, shock absorption, sound damping, tear resistance, and abrasion loss. Enjay Company, Inc, 15 W 51 St, NY 19, NY.

(C-11) **Stock Molded Plastic Parts**—Catalog, 5 pp. Photos and description of various parts available from stock molds including knobs, handles, and handwheels. Dimco-Gray Co, 207 E 6th St, Dayton 2, Ohio.

(C-12) **Thermoplastic Extrusions**—Bulletin, 6 pp. Illustrates and describes custom extrusions from thermoplastics for original equipment requirements. Lists laboratory, engineering and development facilities available. The Conneaut Rubber and Plastics Co, PO Box 257, Conneaut, Ohio.

(C-13) **Carbon Graphite**—Brochure, 8 pp. Charts and tables give data on qualities of sceleroscope hardness, density, temperature limitations, and other properties. Applications shown. The Ohio Carbon Co, 12508 Berea Rd, Cleveland 11, Ohio.

(C-14) **Glass-reinforced Plastics**—Catalog 32 pp. Molding processes and physical properties of fiberglass reinforced plastics. Molded Fiber Glass Co, 4401 Benefit Ave, Ashtabula, Ohio.

(C-15) **Vitreous Ceramics**—Catalog, 16 pp. Describes complete mechanical and electrical properties, metalizing, machining and other features of ceramic bodies. Centralab Div of Globe Union, Inc, 900 E Keefe, Milwaukee, Wis.

(C-16) **Plastic Resins**—Brochure, 8 pp. Characteristics, types, uses of polyvinyl chloride resins; polyester resins; and resin-rubber blends. Naugatuck Chemical Div, United States Rubber Co, Elm St, Naugatuck, Conn.

(C-17) **Carbon and Graphite Products**—Catalog, 55 pp. Describes grades and characteristics for various applications. Stackpole Carbon Co, 1942 Stackpole St, St Marys, Pa.

(C-18) **Rubber and Vinyl Parts**—Bulletin 6 pp. Describes facilities and services for manufacture of molded, extruded, and bonded to metal component parts of natural, synthetic and silicone rubbers, polyurethane and flexible vinyl. The Ohio Rubber Co, Willoughby, Ohio.

(C-19) **Glass Fabrics**—Brochure, 15 pp. Brief resume of products and facilities. Coast Mfg & Supply Co, Box 71, Livermore, Calif.

(C-20) **Thermoplastic Materials**—Brochure, 4 pp. Development of various products such as air conditioners, television lenses, radio cabinets, and others by the injection molding process. Also illustrates the product development, engineering, molding plant, and finishing facilities. Amos Molded Plastics Div, Amos Thompson Corp, Kyle St, Edinburg, Ind.

(C-21) **Plastic Products**—Catalog, 32 pp. Describes characteristics of Teflon available in sheet, rod, tube and tape form. Other products include bondable teflon adhesives, machined parts, tubing and others. Raybestos-Manhattan, Inc, Plastic Products Div, Manheim, Pa.

(C-22) **Structural Adhesive**—Bulletin, 4 pp. Contains properties, test results and ordering information for adhesive with aircraft or missile applications. Adhesive Engineering, Div of Hiller Aircraft Corp, 1411 Industrial Rd, San Carlos, Calif.

(C-23) **Nylon Bobbins and Washers**—Bulletin, 4 pp. Gives engineering specifications, checklist of advantages and description of products. Cosmo Plastics Co, 3239 W 14th St, Cleveland 9, Ohio.

(C-24) **Teflon Materials**—Bulletin, 4 pp. Includes characteristics, uses and electrical properties of tape, sheet and cylinder forms. Enflo Corp, Fellowship Rd & Rt 73, Maple Shade, NJ.

(C-25) **Foamed Plastic**—Brochure, 28 pp. Data on chemical makeup and basic properties along with applications of flexible and poured urethane foams. Nopco Chemical Co, 175 Schuyler Ave, North Arlington, NJ.

(C-26) **Solid-glass Headers**—Brochure, 6 pp. Shows dimensions for standard models, construction details and performance characteristics. Fusite Corp, 6000 Fernview Ave, Cincinnati 13, Ohio.

(C-27) **Thermoplastic Sheet**—Catalog, 48 pp. Gives data on low pressure forming: materials, storage, cutting and layout, machining and trimming, assembly, design and cost factors. Bolta Products Div, The General Tire & Rubber Co, 70 Garden St, Lawrence, Mass.

(C-28) **Molded Rubber Products**—Catalog, 12 pp. Describes standard suction cups and bumpers. Lists typical custom rubber products and specifications. Paul-Martin Rubber Corp, 380 Dwight St, Holyoke, Mass.

(C-29) **Polyethylene Resin**—Bulletin, 8 pp. Describes typical properties and uses of low molecular weight polyethylene resin designed primarily for use in the packaging field. Eastman Chemical Products, Inc, Chemicals Div, Kingsport, Tenn.

(C-30) **Polyethylene Waxes**—Brochure, 26 pp. Describes properties and uses of poly-

ethylene waxes. Gives emulsification procedures and formulations for polishes and leveling agents. Eastman Chemical Products, Inc, Chemicals Div, Kingsport, Tenn.

(C-31) Aluminum Lacquer—Catalog, 4 pp. Describes application of butyrate lacquer for protection of both old and new aluminum surfaces. Suggests pretreatment methods. Eastman Chemical Products, Inc, Chemicals Div, Kingsport, Tenn.

(C-32) Sucrose Acetate Isobutyrate—Bulletin, 12 pp. Describes physical properties and suggested uses. At 30 C, SAIB has a viscosity of 100,000 cps, at 100 C the viscosity is 90 cps. Eastman Chemical Products, Inc, Chemicals Div, Kingsport, Tenn.

(C-33) High-pressure Laminated Plastics—Catalog, 4 pp. Describes 34 grades made to meet or exceed NEMA specifications. Also sizes, tolerances, thickness range are included. Plastics Div, Farley & Loetscher Mfg Co, 7th & White Sts, Dubuque, Ia.

(C-34) Ceramic Coatings—Bulletin, 10 pp. Describes various ceramic coatings which protect underlying material from high temperatures and abrasion. Gives properties, applications and process for applying. Norton Co, New Bond St, Worcester 6, Mass.

(C-35) Colloidal Dispersions—Bulletin, 4 pp. Describes line of dispersions: colloidal graphite, molybdenum disulfide, tetrafluoroethylene, vermiculite, glass, mica and other solids. Includes typical applications and physical data for each product. Acheson Colloids Co, 1635 Washington Ave, Port Huron, Mich.

(C-36) Crepe Paper—Brochure, 8 pp. Describes nature of material and some present end uses. Contains table of physical properties, treatments and combinations in which material is available. Cincinnati Industries, Inc, PO Box 38, Lockland 15, Ohio.

(C-37) Protective Coatings—Bulletin, 5 pp. Single package protective coatings for iron, steel and aluminum requires no mixing or special proparation of surfaces. Description, specifications for military and commercial uses. Industrial Metal Protectives, Inc, 404 Homestead Ave, Dayton 8, Ohio.

(C-38) Teflon Parts—Brochure, 4 pp. Photographs showing intricate moldings, physical properties chart, and other pertinent data. Sparta Manufacturing Co, Div of United States Ceramic Tile Co, Dover, Ohio.

(C-39) Magnetic Rubber—Bulletin, 4 pp. Describes a flexible magnetic material, resistant to oils and acids, available in molded or sheet form. Gives basic characteristics and properties of the material and typical applications. Denman Rubber Mfg Co, PO Box 951, Warren, Ohio.

(C-40) Plastic Piping Systems—Catalog, 16 pp. Describes materials, installation methods, and gives chemical resistance data on chemical reagents for basic plastic piping systems materials. Chemtrol Corp, 10872 Stanford Ave, Lynwood, Calif.

(C-41) Nonflammable Baking Finishes—Brochure, 4 pp. Primers, baking enamels and clear coatings for steel, nonferrous metals, plastics, ceramics, and others based on water emulsions. Universal Paint & Varnish, Inc, PO Box 199, Northfield & Krick Roads, Bedford, Ohio.

(C-42) Industrial Grade Laminates—Catalog, 18 pp. Technical and price information for epoxy glass and paper; phenolic canvas, paper and laminates; plain and copper clad. Also special laminates. New England Laminates Co, Inc, 481 Canal St, Stamford, Conn.

(C-43) Polyethylene Products—Catalog, 40 pp. Describes end-uses of polyethylene in many different product fields; illustrated. Lists range of properties. Eastman Chemical Products, Inc, Kingsport, Tenn.

(C-44) Cellular Rubber and Plastics—Catalog, 8 pp. Compounds, forms, applications and properties of cellular rubber and plastics. B F Goodrich Sponge Products, Shelton, Conn.

(C-45) Extruded Plastic Parts—Brochure, 12 pp. Summarizes general specifications for custom extrusions. Contains design ideas for applications of extrusions, brief resumes of thermoplastics used, and a property table. Anchor Plastics Co, Inc, 36-36 36th St, L I City 6, NY.

(C-46) Molded Rubber Products—Brochure, 12 pp. Describes machinery and operations used in molding rubber parts. Gives engineering and ordering information. Paeco Rubber Co, 225 W Lake St, Ravenna, Ohio.

(C-47) PVC Parts—Bulletin, 16 pp. Data on selection, application and installation of standard and high-impact PVC. Mechanical, thermal, electrical properties, chemical resistance tables, sizes, specifications and cost comparisons with metal pipe. Carlon Products Corp, Box 133, Aurora, Ohio.

(C-48) Petroleum Base Lubricants—Catalog, 12 pp. Lists and describes cutting, quenching, hydraulic and other metalworking oils; rubber process aids, greases and petrochemicals are also covered. Sun Oil Co, 1608 Walnut St, Phila 3, Pa.

(C-49) Custom Moldings—Brochure, 8 pp. Describes material, molding facilities; illustrates examples of current production; and suggests possible applications of fiberglass reinforced polyester. G B Lewis Co, 426 Montgomery St, Watertown, Mass.

(C-50) Molded Rubber—Bulletin, 46 pp. Provides design information regarding the properties and applications of molded rubber as an engineering material. Stowe-Woodward, Inc, Newton Upper Falls, Mass.

(C-51) Polyester Resins—Catalog, 72 pp. Complete information on polyester resins for hand lay-up, premix compounds, and matched die molding applications. Also information on gel coats, color concentrates, activators, and others. Interchemical Corp, Finishes Div, 1754 Dana Ave, Cincinnati 7, Ohio.

(C-52) Coatings—Bulletin, 8 pp. Basic engineering data on wire and powder sprayed coatings of metals and ceramics. Metallizing Engineering Co, Inc, 1101 Prospect Ave, Westbury, NY.

(C-53) Chemical Coatings—Bulletin 4 pp. Describes types of bonderites available for treating aluminum; method of application and test results. Shows typical uses and advantages. Parker Rust Proof Co, 2177 E Milwaukee, Detroit 11, Mich.

(C-54) Teflon Films—Catalog, 15 pp. Describes construction of very thin teflon films, technical data, suggested applications and ordering information. Dilectrix Corp, Allen Blvd & Grand Ave, Farmingdale, NY.

(C-55) Polyethylene Resins—Brochure, 12 pp. Essential properties of the basic resins are presented in chart form. Suggested resins for most frequently occurring requirements are also included. US Industrial Chemicals Co, Div of National Distillers & Chemical Corp, 99 Park Ave, New York 16, NY.

(C-56) Porcelain Enamel—Bulletin 4 pp. Describes attributes and physical properties of porcelain enamel as applied to small steel, copper and stainless steel components. Erie Ceramic Arts Co, 3120 W 22nd St, Erie, Pa.

(C-57) Dry Lubricant Coatings—Brochure, 8 pp. Describes method of application, case histories, properties and gives suggested uses and facilities available. Everlube Corp, 6940 Farmdale, North Hollywood, Calif.

(C-58) Optical-fused Quartz—Catalog, 4 pp. Characteristics of various grades and chart on transmission of entering energy. Engelhard Industries, Inc, 113 Astor St, Newark, NJ.

(C-59) Reinforced Teflon—Bulletin, 9 pp. Describes physical characteristics, fabrication, maximum service temperature and approved uses in the chemical process, aircraft, missile, and electronic industries. Rogers Corp, Rogers, Conn.

(C-60) Hardboard Products—Catalog, 12 pp. Describes various hardboards, listing their properties, applications and construction methods. Masonite Service Bureau, Masonite Corp, Suite 2037, 111 W Washington St, Chicago 2, Ill.

(C-61) Plastic Materials—Bulletin, 8 pp. Includes uses, characteristics, and special properties of phenolic molding compounds, fire-retardant polyester resins, phenolic bonding and coating resins. Selection guide to representative materials lists detailed physical and electrical properties. Durez Plastics Div, Hooker Chemical Corp, 1514 Walck Rd, North Tonawanda, NY.

To materialize your design ideas...

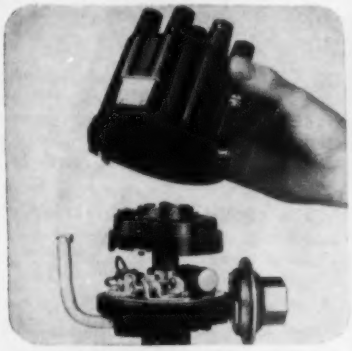
PLASTICS and

DUREZ PHENOLIC Molding Compounds

GENERAL-PURPOSE. The lowest-cost phenolic materials, most widely used for housings, cases, and large and small parts requiring balanced properties: impact strength, non-conductivity, and lustrous finish with resistance to heat and cold, water, and mild chemicals.

IMPACT. A class of materials designed for applications subject to heavy wear or rough handling, such as telephone parts, automotive pump gears, bushings, caster wheels, tool parts, pulleys, and structural components. Various types of reinforcing fillers provide high impact strength.

NON-BLEEDING. Lustrous molded appearance, resistance to moisture, and high torque strength have gained wide preference for these Durez phenolics. Typical uses: closures for medicinal, cosmetic, and other packaged products, especially those containing liquids with alcohol.



ELECTRICAL. For automotive, radio, TV transformer, X-ray, switch, appliance, and other equipment parts requiring high dielectric strength, low dissipation factor, and high volume resistivity. Like all Durez phenolics, their desirable properties include light weight and lustrous molded-in finish.

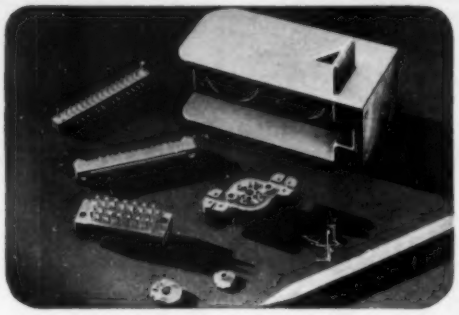
HEAT RESISTANCE. This characteristic is combined with electrical strength and good molding properties in this class of compounds designed for electric appliance and cooking utensil parts where heat resistance is a major factor in durability and safety.

SPECIAL PROPERTY. Unusual combinations of properties are available in this class of phenolics. Some have low modulus of elasticity, others good conductivity, others excellent chemical resistance. By formula variation, Durez phenolics are made to meet industrial needs.

For designers and engineers seeking new and better ways to express their product ideas, DUREZ materials provide an inexhaustible source of answers. Whether your requirements are attractive appearance, long service or low cost, evaluation of the properties of these thermosetting materials and their interesting combinations will start you on the right track. Full information about properties and uses awaits your request, and the experience of 35 years in pioneering with plastics is available to help you solve your design, structural, and production problems.

RESINS that fit the job

DUREZ DIALLYL PHTHALATE Molding Compounds

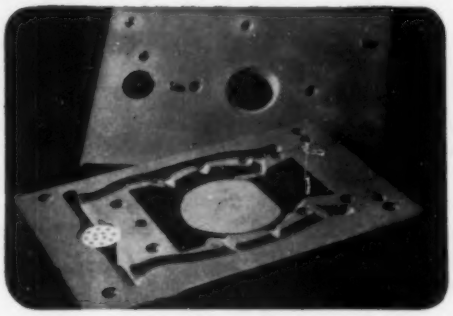


Available in orlon-filled and mineral-filled types, these thermosetting materials give outstanding service in electrical applications under prolonged exposure to high humidity. They possess exceptional electrical properties, low water absorption, and high impact strength, open new areas of engineered applications to the advantages of molded components.

HETRON® Flame-Retardant POLYESTER Resins

Self-extinguishing and exceptionally resistant to heat degradation, HETRON has *permanent* fire resistance without the use of additives. Impervious to chemical attack. Mechanically stronger than most resins. Has many applications in electrical, automotive, and aircraft parts and housings, boat hulls, radomes, chemical ductwork, tanks, blowers, and structural panels.

DUREZ PHENOLIC Resins



For bonding, impregnating, laminating, coating. Industrial types include shell mold resins for metal casting, others that improve the characteristics of abrasives, friction materials, rubber compounds, reconstructed wood, and acid-proof cements. Coating resins contribute important properties in wax emulsions, brushing and spraying finishes, printing inks.

FACTS, IDEAS for Your File

Send for illustrated bulletins and data sheets containing full descriptions of Durez materials—properties, uses, helpful design suggestions, facts on molding, machining, finishing. For the latest on applications, ask us to send you "Durez Plastics News," mailed periodically. It's packed with information on new products and product improvement.

DUREZ®

Plastics and Resins that Fit the Job

DUREZ PLASTICS DIVISION
HOOKER CHEMICAL CORPORATION
1514 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICALS PLASTICS

WRITE 129 ON READER SERVICE CARD 129

Mechanical interlocking alone is used to join Dacron,* Orlon* and other synthetic fibers used in new TROYFELT non-woven fabrics. (*DuPont tradenames)

INTRODUCING TROYFELT

a versatile new family of synthetic felts made without chemical binders

Where can you use these amazing new felts? Field-tested and proved for more than two years, these are typical reports:

A FILTER MAKER reports TROYFELT outperforming wool felts 7 to 1 in filtering highly abrasive Taconite ore.

AN ELECTRONICS firm finds TROYFELT a superior packing because it stays resilient at high and low temperatures.

A CUTLERY MAKER uses TROYFELT to polish stainless ware . . . finds its smooth surface gives higher luster, lasts longer.

. . . window makers use it as an impervious life-time seal . . . shoe makers because it lasts longer as a padding . . . gasket makers because it die cuts without ravelling . . . it's also used as wadding in cartridges . . . as a vibration isolator.

WHAT IS TROYFELT?

. . . basically, TROYFELT is a non-woven synthetic felt. It is available in Dacron, in Orlon, and in other synthetics. Unlike other non-wovens it has no chemical binders . . . the individual fibers are joined mechanically. Thus it is a softer material, a better insulator, a better filter, a better packing, padding and wick.

And yet TROYFELT *offers all the long-lived properties of the synthetics: a marked resistance to chemical attack, heat, abrasion and wear!*

Want *all* the facts? Just circle the number below on this magazine's handy reply card.

TROYFELT ... *by the pioneers in non-woven synthetic felts*

INDUSTRIAL PRODUCTS DIVISION • TROY BLANKET MILLS

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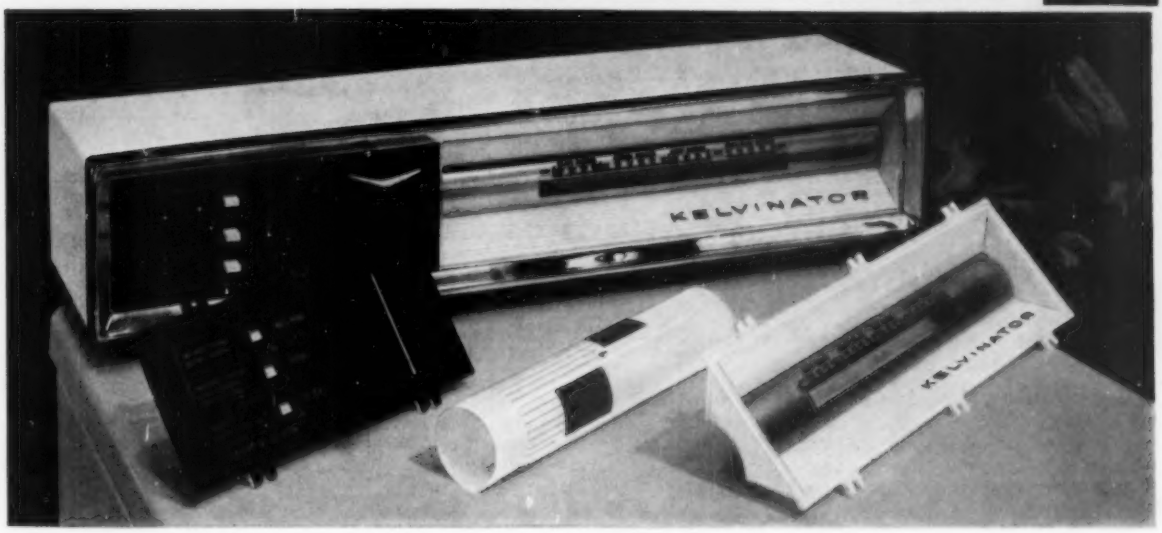

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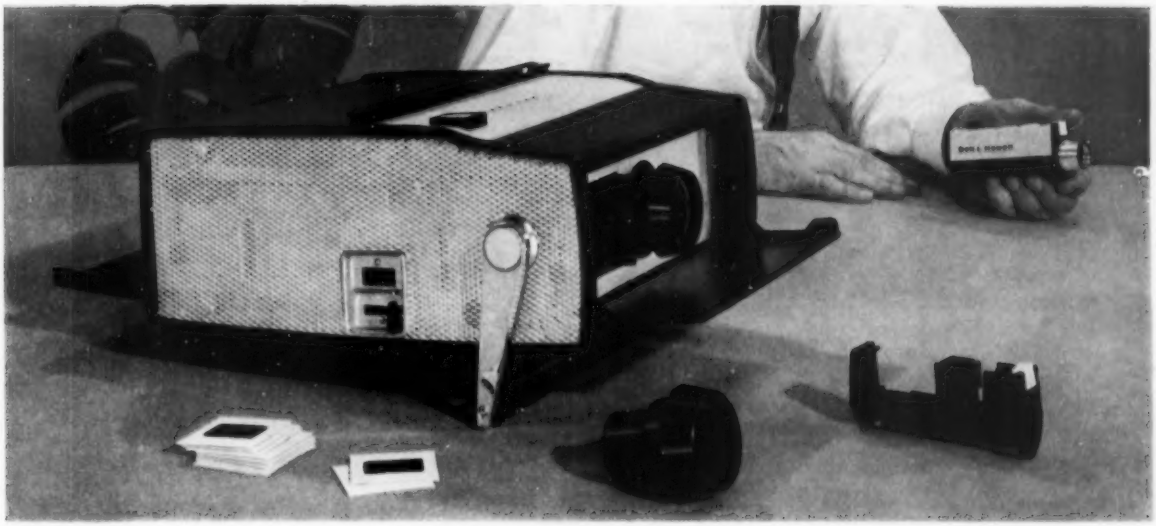
Plexiglas...Implex



for Kelvinator . . . PLEXIGLAS® acrylic plastic provides both beauty and strength for the handsome control panel on 1959 automatic clothes dryers. Pushbutton panel, backlighted Cycle-Vu window panel and rotary dial behind window are all made of PLEXIGLAS.

for Bell & Howell . . . Tough new IMPLEX® high-impact acrylic plastic gives outstanding strength and resistance to staining in components of "Explorer" slide projectors. Lens barrel container, and housing of Point-A-Ray remote control unit, are molded of IMPLEX.

for you . . . PLEXIGLAS and IMPLEX may be just what you need to give your products added sales appeal. Our design staff and technical representatives will be glad to tell you about these Rohm & Haas molding materials.

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WRITE 131 ON READER SERVICE CARD 131

VINYL-METAL LAMINATES IN DESIGN

CLAD REX

The broad effect of CLAD-REX® on industrial design, engineering, and selection of materials

Reaction to the potential offered by vinyl-clad metals is contradictory. The potential advantage is so broad that it's hard to believe. But, when full realization does begin to develop, enthusiasm tends to go too far!

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

Clad-Rex is a vinyl-metal laminate. Specifically, a calendered, semi-rigid poly-vinyl chloride film bonded to sheet metal. All alloys and tempers of aluminum and steel (including galvanized and aluminized) are commonly used. However, other metals can be used where their special properties are important to end product performance.

The sales appeal of Clad-Rex vinyl-metal laminate

The words *calendered* and *film* mean styling in Clad-Rex is unlimited, because film can be printed. Simulated wood-grains and leathers, as well as any color, combination of colors, texture or pattern can be used. Or you can design your own, if you prefer.

This unlimited choice ranges from sparkling burnishes including high metallics, to non-reflective matte finishes (or variations between) as well.

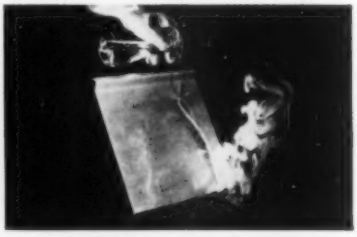
The abrasion resistance of Clad-Rex vinyl-metal laminates

The words *semi-rigid* and *poly-vinyl chloride film* mean Clad-Rex has unusual resistance to abrasion. Therefore, products made of Clad-Rex are more durable and suited to usage where abrasion resistance is required.

However—most important to manufacturing—Clad-Rex can be processed without the careful handling or rejects common to other pre-finished metals. This advantage in itself results in a substantial saving in cost. Even the finishing of *un*finished metals leads to a reject factor that becomes a savings when Clad-Rex is used.

The corrosion resistance of Clad-Rex vinyl-metal laminates

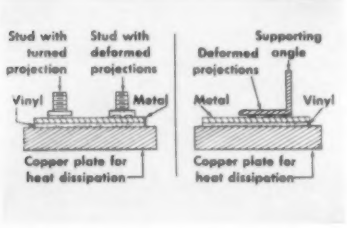
The words *poly-vinyl* and *chloride* become important again, because of the inherent properties of the Clad-Rex vinyl. It provides excellent resistance to acids and alkalis, as well as other corrosive chemicals. It also has high dielectric properties.



The fabrication of Clad-Rex vinyl-metal laminates

Clad-Rex can be formed in almost as many ways as any *un*finished sheet metal—including deep drawing!

Resistance welding, generally, is limited to projection techniques.



However, the resistance welding equipment must be (1) tooled for series welding procedures (both electrodes on same side of sheet), and (2) capable of very short weld times with extremely fast follow-up of forging pressure.

Epoxy resins are proving quite successful for assembly. Clamps can be eliminated by using resistance weld tacking or interlocking design.

The cost advantage of Clad-Rex vinyl-metal laminates

As a purchased material going into a user's plant, vinyl-metal laminates cost more than *un*finished or some other pre-finished metals. *But, most important, end products made of Clad-Rex generally cost less!*

The reasons are worthy of close examination:

(1) Parts made of Clad-Rex require no further finishing. This is a savings in equipment, finishing material, factory floor space, labor, handling, etc.

(2) The abrasion resistance of Clad-Rex substantially reduces (and often eliminates) rejects. This includes both rejected products *and* the expensive handling, reworking activities, and labor required.

The broad effect of Clad-Rex vinyl-metal laminates on manufacturing literally simplifies your processing operations. Movement of sub-assemblies, etc., through your plant actually becomes more direct—out of your dies into assembly!

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. Free of charge, a Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product. **Clad-Rex Division of Simoniz Company, 2117 Indiana Avenue, Chicago 16, Illinois. Telephone: VIctory 2-7272.**

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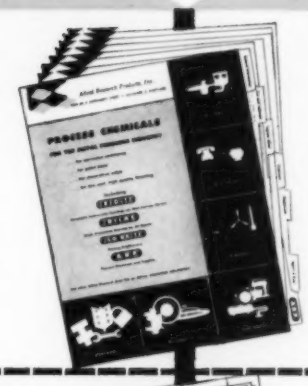

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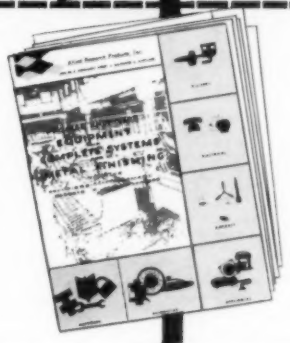

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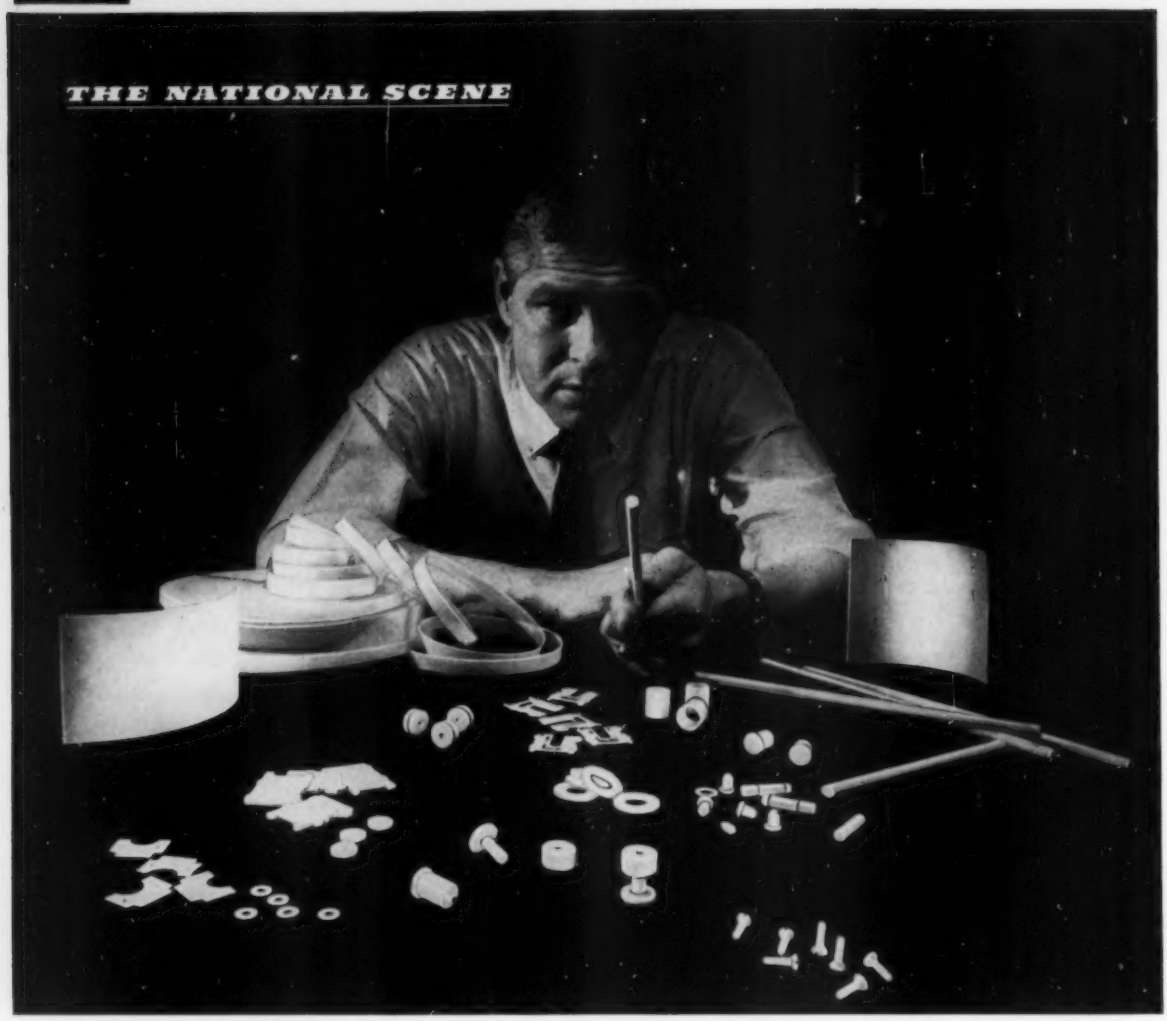

"Inspect the product-improving, cost-cutting metal-like properties of new DELRIN®"

National can now furnish extrusions or fabricated parts of this remarkable new Du Pont thermoplastic

If you have not yet evaluated this exciting new material you will want to. Exhaustive tests show that "Delrin" can compete on a cost and performance basis with parts made of many metals, rubber, glass or wood. It may be the *one best material* to solve a current problem for you.

In adding "Delrin" to its family of thermoplastics, National continues the policy of offering the designer industry's widest selection of basic materials—over 100 types and grades. "Delrin" is available in extruded rod, strip, and special shapes, or in precision fabricated parts to your design. You can depend on National's production experience for sound help on "Delrin" applications.

Sizes now available include: rod—$\frac{1}{4}$" to 2" diameter; strip —.020" through .093" thick, up to 7" wide.

Special extruded shapes available upon request. Fabricated "Delrin" parts now being furnished National's customers indicate broad application wherever strength, rigidity and dimensional stability are important.

For specific information, prices and personal assistance on the use of "Delrin"—or any of the more than 100 National materials—write National Vulcanized Fibre Co., Dept. H-9, Wilmington, Delaware. Or contact your nearby National Sales Office.

1. Extruded strip. 2. Slit-to-width strip. 3. Extruded rod. 4. Machined pulleys. 5. Punched terminal bases. 6. Bushings. 7. Terminal plugs. 8. Punched discs. 9. Punched washers. 10. Parts made in automatic screw machines. 11. Machined bolts.

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Vulcanized Fibre: 10 standard grades; many special grades.

PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, teflon or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

Extruded Nylon, "Delrin", "Penton": rod, strip, tubing, special shapes.

Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

PHENOLITE Copper-Clad Laminates: 10 standard grades.

Combination Materials: Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

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Baltimore ..... VAlley 3-0393
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Newark ..... MItchell 2-6090
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Rochester ..... Hillside 5-0900
St. Louis ..... PArkview 5-9577
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San Francisco ..... DAvenport 6-4667
Seattle ..... MElrose 2-7298
Wilmington ..... OLympia 5-6371

IN CANADA:
National Fibre Co. of Canada, Ltd.
Toronto ..... LEnnox 2-3303
Montreal ..... AVenue 8-7536

NATIONAL VULCANIZED FIBRE CO.
WILMINGTON 99, DELAWARE
In Canada:
NATIONAL FIBRE COMPANY OF CANADA, Ltd., Toronto 3, Ontario

catalogs and bulletins.....continued

(C-62) Flexible Rubber Pipe—Catalog, 4 pp. Gives construction features, applications and ordering data as well as coupling advantages. Raybestos-Manhattan Inc, Passaic, NJ.

(C-63) Plastic Closures—Bulletin, 16 pp. Summarizes data on line of threaded and nonthreaded caps and plugs for safeguarding products in process, storage or transit. Dimensions and price sheets for stocked sizes. Caplugs Div, Protective Closures Co, Inc, 2207 Elmwood Ave, Buffalo, NY.

(C-64) Hydraulic Fluids—Brochure, 20 pp. Describes the characteristics of petroleum base and fire resistant hydraulic fluids for industrial use. Includes selection and maintenance recommendations. Vickers Inc, A & E Center, Detroit 32, Mich.

(C-65) Rust Preventives—Bulletin, 8 pp. Data sheets covering emulsifiable, solvent-cutback, hot-dip and oil-types for protecting parts in process, shipment, and storage. Esso Standard Oil Co, 15 W 51 St, NY 19, NY.

(C-66) Multi-purpose Grease—Brochure, 4 pp. Describes grease which is suitable for high temperatures, water resistant, and has extreme pressure properties. Esso Standard Oil Co, 15 W 51 St, NY 19, NY.

(C-67) Engineered Plastic Products—Catalog, 25 pp. Describes properties and raw materials of the fluorocarbons and other industrial plastics. Product category covers electrical-electronic insulation materials through hydraulic-pneumatic seals with standard specification sheets. W S Shamban & Co, 11617 W Jefferson Blvd, Culver City, Calif.

(C-68) Teflon Tapes—Brochure, 4 pp. Gives temperature range, properties and applications for pressure sensitive and thermal curing tapes. The Connecticut Hard Rubber Co, 407 East St, New Haven, Conn.

(C-69) Urethane Coatings—Bulletin, 4 pp. Describes properties, characteristics and application techniques of urethane coatings for metal, wood, concrete, leather, rubber and plastics. Mobay Chemical Co, 1815 Washington Rd, Pittsburgh 34, Pa.

(C-70) Custom Injection Molded Plastics—Brochure, 12 pp. Case histories showing the treatment of injection molded problems and description of facilities. Nosco Plastics, Inc, Box 269, Erie, Pa.

(C-71) Lubricants—Bulletin, 4 pp. Describes how lubricants can be selected for correct application to difficult lubrication problems. The Alpha-Molykote Corp, 65 Harvard Ave, Stamford, Conn.

(C-72) Vacuum and Pressure Bag Molding—Bulletin, 6 pp. Describes the advantages and limitations, tooling and choice of materials for production molds. Also covers the techniques used for producing reinforced plastic parts by these processes. Celanese Corp of America, Plastics Div, 744 Broad St, Newark, NJ.

(C-73) Cast Urethane Elastomers—Brochure, 12 pp. Contains description of basic properties, characteristics, general design and engineering data for solid cast urethane elastomers. Illustrated applications. Mobay Chemical Co, 1815 Washington Rd, Pittsburgh 34, Pa.

(C-74) Polystyrenes—Bulletin, 24 pp. Discusses applications, types, design considerations, fabricating techniques, finishing operations, special services. Provides sales information and summary of nomenclature. Koppers Co, Inc, Koppers Bldg, Pittsburgh 19, Pa.

(C-75) Industrial Organic Chemicals—Brochure, 36 pp. Compendium of reactions and uses of phthalonitrile, and its reaction products—the phthalocyanines. Includes properties. Plastics & Coal Chemicals Div, Allied Chemical Corp, 40 Rector St, NY 6, NY.

(C-76) Industrial Finishes—Catalog, 39 pp. Describes colors, baking and drying schedules, application and selection of lacquers, enamels, synthetics and special finishes. Maas & Waldstein Co, 2121 McCarter Highway, Newark, NJ.

(C-77) Adhesives, Coatings and Sealers—Catalog, 12 pp. Describes design concepts, typical applications and general characteristics of various products. Diagrams, photographs and sales information. Adhesives, Coatings & Sealers Div, Minnesota Mining & Mfg Co, 900 Bush Ave, St Paul 6, Minn.

(C-78) Nonporous Rubber Materials—Brochure, 4 pp. Available in sheets or strips, cemented or vulcanized bonds. Gives applications, properties and specifications. Roth Rubber Co, Div of Vapor Heating Corp, 1860 S 54th Ave, Chicago 50, Ill.

(C-79) Plastic Strippable Coatings—Brochure, 4 pp. Describes spray-on, strip-off coating for protection of surfaces during manufacturing process, painting, storage or shipment. Spraylat Corp, 1 Park Ave, NY 16, NY.

(C-80) Laminated Plastic—Catalog, 8 pp. Applications, properties and ordering information for sheets, tubes, rods and copper clad materials. Includes comparison charts on grades. Formica Corp, 4614 Spring Grove Ave, Cincinnati, Ohio.

(C-81) Epoxy-glass Laminate—Brochure, 4 pp. Describes use in printed circuits, electrical properties and types of processing it will withstand. General Electric Co, 1 Plastics Ave, Coshocton, Ohio.

(C-82) Synthetic Crystals—Brochure, 4 pp. Types, forms, uses and properties of synthetic sapphires, rutiles, and rubies. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY 17, NY.

(C-83) Protective Coatings—Bulletin, 13 pp. Describes nature, general properties and specific resistances. Includes product listing, specifications and typical uses. Plastics & Coal Chemicals Div, Allied Chemical Corp, 40 Rector St, NY 6, NY.

NONMETALLIC MATERIALS AND FINISHES

Information Bulletin

CHEMICAL PREPAINT TREATMENTS FOR METAL SURFACES

What they do, the types available, how they are applied

By J. H. GEYER, Manager, Product Development Dept., AMCHEM PRODUCTS, INC.

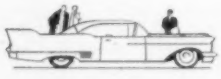
Paint systems have been steadily improved in an effort to produce more decorative, easier-to-apply, and more corrosion-resistant films. The ability, however, of any paint film to perform its predetermined functions cannot be fully utilized without properly preparing the metal surface.

Chemical *prepaint* treatments are designed to do four jobs and do them well. First, they remove organic soils, shop dirt, scale, and rust or corrosion products from the metal surface. Second, they provide surfaces that are completely compatible with subsequent paint films. Third, they produce a *tooth* that promotes good paint film adhesion. Fourth, they effectively prevent underpaint corrosion growth after any breakthrough in the paint film.

Basically, there are four types of chemical prepaint treatments—phosphoric acid, iron phosphate, zinc phosphate, and amorphous phosphate or chromate.

Phosphoric Acid—Phosphoric acid cleaner combination materials are an example of economical chemical prepaint treatments. Amchem Deoxidine is such a material. It removes organic soils, rust, scale and contaminating elements from the metal surface. It also produces a light etch on steel, aluminum or zinc surfaces which considerably aids in increasing paint adhesion. It does not, however, form an actual coating on the metal surface. Any breakthrough in the subsequent paint film will permit underfilm corrosion to proceed. Grades of Deoxidine are available for application by brush or swab, hot and cold dip, or hot spray.

Iron Phosphate—Iron phosphating processes are extensively used in the chemical prepaint treatment of appliances—water heater shells, ranges, washers, dryers and other *white lines*. These processes will produce excellent paint-bonding films on the metal and retard or prevent underpaint corrosion. Duridine, Amchem's iron phosphating process, is a combination organic soil cleaner and iron phosphate coating material. Both the cleaning and coating operations take place in the same bath. Duridine and other iron phosphates do not lend themselves to brush-on application, are primarily designed for spray type equipment of four or five stages. But several dip installations are successfully operating today by inclusion of an alkali precleaning stage.



Zinc Phosphate—Amchem Granodine is an example of zinc phosphating, the type now being used to treat steel in the automotive industry, and predominantly specified for steel ordnance and military items. This process forms a coating which offers the ultimate in paint adhesion promotion and vastly augments the corrosion resistance of subsequent paint films. Zinc phosphate materials are extremely flexible as to method of application—can be applied by brush, dip or automatic spray equipment. In a typical dip or power spray system, the stages would be alkali clean, water rinse, zinc phosphate treatment, water rinse, acidulated final rinse. If the metal has considerable areas of rust or scale, an acid pickle is advisable following the alkali cleaning stage.

On zinc surfaces, the zinc phosphates perform a rather unique function. They act as a barrier against chemical reaction between the applied paint film and the zinc surface. This effectively prevents blistering of the paint and early breakdown of the film. This is in addition, of course, to the improvement of paint adhesion and the retarding of underpaint corrosion. Amchem Lithoform is specially designed for use over zinc surfaces and finds wide application as a prepaint treatment for ornamental zinc die castings, refrigerator liners, and on most galvanized work requiring painted finishes.

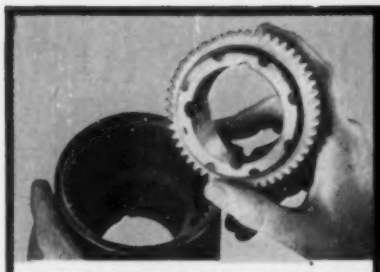
Amorphous Phosphate and Chromate—These coatings are the films produced by the Amchem Alodine processes and similar ones on aluminum surfaces. They have met with wide acceptance in the prepaint treatment of venetian blind strips, refrigerator liners, aluminum heat transfer units, aircraft sheet metal assemblies, and many other items fabricated from aluminum. The various coatings provide an excellent film for the promotion of paint adhesion and effectively prevent underfilm corrosion. As in the case of zinc, aluminum exhibits a tendency to chemically react with some paint systems. The Alodine processes develop a barrier film between the paint and the aluminum surfaces which prevents this reaction. The Alodines are extremely versatile materials that can be applied to aluminum surfaces by brush, hand spray, dipping, or mechanical spraying. Brush application is particularly well adapted to the processing of parts too large for simple dip systems or in manufacturing operations that do not warrant a tank setup. In dip or spray application, the system usually consists of an alkaline preclean, a water rinse, the Alodine treatment, a water rinse, and an acidulated final rinse. Where the surface is heavily oxidized, a deoxidizer in the line is needed.

For more complete information about any one or all of these chemical conversion coatings, contact an Amchem sales representative or write us at Ambler 23, Pa.

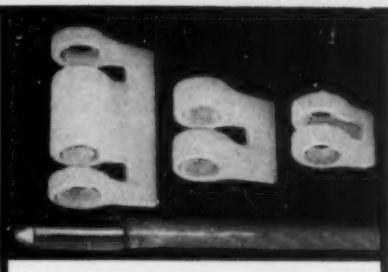
AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)

AMBLER 23, PA. • Detroit, Mich., St. Joseph, Mo., Niles, Calif., Windsor, Ont.

Amchem, Granodine, Deoxidine, Duridine, Lithoform and Alodine, are registered trademarks of Amchem Products, Inc.

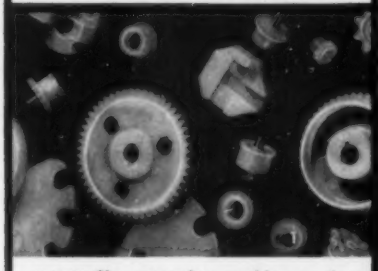


COUPLING employs rugged ring gear of ZYTEL nylon resin. High wear resistance, little or no lubrication are featured. (By Boonton Molding Co., Boonton, N. J., for John Waldron Corp., New Brunswick, N. J.)

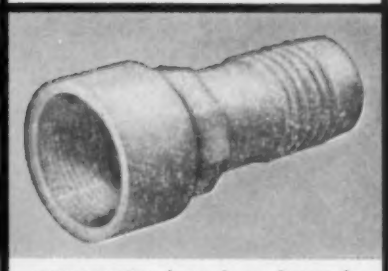


BELT-FASTENER PARTS for power and conveyor belts are made of ZYTEL for high tensile strength. Hinge pin of galvanized cable coated with ZYTEL resists wear. (By Flexible Steel Lacing Co., Chicago, Ill.)

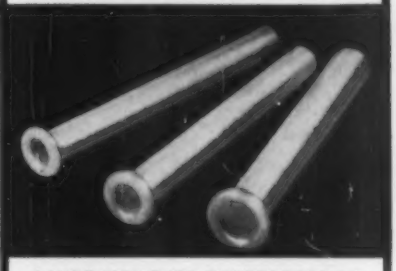
ADDING MACHINE uses cams and other components of ZYTEL for smooth, quiet operation. Elimination of waste and machining steps produces cost savings. (By Underwood Corporation, Hartford, Conn.)



X-RAY film processing machine employs gears and other parts of ZYTEL. Unharmed by photographic chemicals, they lower costs. (By Brook Molding Corp., Norwood, Mass., for Eastman Kodak Co., Rochester, N. Y.)

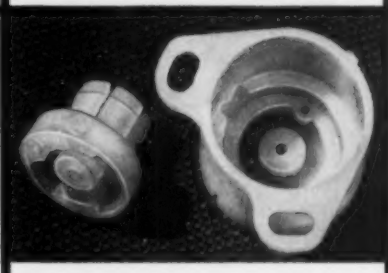


PIPE ADAPTER is tough, won't corrode, costs far less than metal fittings. Made of Du Pont ZYTEL, it is ideal for use with jet pumps and flexible plastic pipe. (Made by Yardley Plastics Co., Columbus, Ohio.)

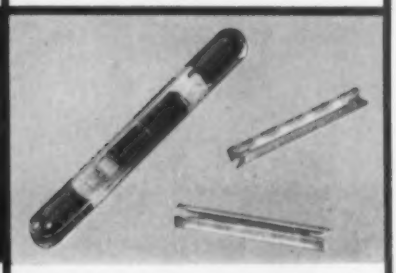


CONDENSER TUBE PROTECTORS are fracture-proof . . . resist sand blasting, corrosion, solvents. Made of ZYTEL nylon resin, they insure smooth flow. (By Crane Packing Co., Morton Grove, Illinois.)

ELECTRIC SHOE POLISHER has eight lightweight components of ZYTEL. The accurate molded parts provide quiet operation, temperature resistance, low operating friction. (Ronson Corp., Woodbridge, N. J.)



COMBINATION back-up lamp and safety switch for 1959 Ford cars provide economy, heat strength. (By United Plastics, Vassar, Mich., for Courter Products Div., of Model Eng. & Mfg., Inc., Boyne City, Mich.)



REEL of ZYTEL holds suture for surgical ligatures . . . permits sterilization in solvents at 300°F. (By Guild Molders, Inc., Elmsford, N. Y., for Ethicon, Inc., Somerville, N. J., a subsidiary of Johnson & Johnson.)

Latest designs show high strength, wide utility of ZYTEL® nylon resins

So versatile are the properties of ZYTEL nylon resins that they can be used to make basic parts you find in almost any mechanism. ZYTEL is an outstanding gear and bearing material. ZYTEL can be used to make fastening elements, casings, seals, electrical hardware, plumbing parts, richly colored components, intricate shapes with high tolerances. ZYTEL in thin sections is tough, flexible, translucent—capable of use for soft-light lenses. ZYTEL in solid shapes has high impact strength and is resistant to abrasion, heat, chemicals. Best of all, ZYTEL is often the most economical material you can use in your designs.

Many molders have the experience to supply you with parts of ZYTEL in quantity to your exact specifications. For design literature you'll find helpful, write to: E. I. du Pont de Nemours & Co. (Inc.). Advertising Department, Room **Z-36-9,** Nemours Bldg., Wilmington 98, Delaware. *In Canada:* Du Pont of Canada Limited, P. O. Box 660, Montreal, Quebec.

ZYTEL®
NYLON RESINS
POLYCHEMICALS DEPARTMENT

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

A NEW HERCULES PLASTIC!

TYPICAL PROPERTIES OF HI-FAX

Crystalline melting point, °F.	268
Specific gravity	0.945-0.947
Mold shrinkage, in./in.	0.022-0.028
Water absorption, %	0.03
Heat-distortion temperature (66 p.s.i.), °F.	144-154
Deformation under 2000-lb load for 6 hr. at 122°F., %	9-16
Hardness, Rockwell R	35-40
Impact, Izod, ft.-lbs./in., notched	1.5-12
unnotched	>32
Tensile yield stress at 73°F., p.s.i.	3450-4500
at 212°F.	1300-1800
Ultimate elongation at 73°F.,%	100-700
Dielectric constant	2.33
Power factor	0.0007

hi-fax®

First of the new Hercules family of plastics, Hi-fax is the Hercules trademark for high-density polyethylene. As produced by an exclusive process, it is superior in many ways to other high-density materials. As a result, Hi-fax offers important advantages to producers in the markets where it now serves. Its superior properties, combined with the outstanding processing economies it affords, yield quality, low-cost products.

Blown containers: Hi-fax is now the standard material by which all plastics used in blown bottles and containers are judged. It provides outstanding performance and economy, especially in products designed to package corrosive materials, offering a high degree of stress-crack resistance coupled with lightweight strength in thin-wall sections.

Industrial shapes: Excellent processability, outstanding low temperature resistance, dimensional stability, and durability in long-term use are characteristic of the many industrial parts now being fabricated with Hi-fax by extrusion and injection molding.

Wire: Wire and cable coatings made with Hi-fax provide a toughness and resistance to abrasion superior to almost any other plastic or rubber.

Pipe: A special pipe grade of Hi-fax yields a low-cost, thin-wall flexible pipe, NSF approved, and setting new standards for quality in flexible piping. Extruders have found it offers many processing advantages over competitive materials.

Flexible Pipe

Wire and Cable Coatings

Containers

Cosmetic Packaging

Detergent Bottles

Want to know more about Hercules' NEW PLASTIC
For complete property and use data, or specific informat
on any of the products shown here, call or write:

ANOTHER NEW HERCULES PLASTIC!

Hospitalware

Packaging

Dinnerware

Appliances

Housewares

Film

Product Components

Pro-fax, the bright new name in thermoplastics, is the Hercules trademark for polypropylene. With a high softening point, Pro-fax is dimensionally stable at temperatures as high as 300°F. It has a hard, glossy surface finish, and is available in a full range of opaque and translucent colors. With a specific gravity of only 0.9, *Pro-fax is the lightest of all plastics,* providing a production bonus of many extra parts per pound over other materials in its same price-property class.

Pro-fax for injection molding: Pro-fax is an excellent general-purpose material now finding broad use in such markets as closures and containers, automotive and appliance parts, valves and fittings, housewares, toys, and sporting goods. Pro-fax molds rapidly and well, has only half the shrinkage of high-density polyethylene.

Pro-fax for extrusion: Pro-fax monofilaments are now in growing use in rope, fish nets, seat cover fabrics, outdoor furniture webbing, bristles, pen tubes, and a variety of industrial parts. Extruded Pro-fax sheet provides a splendid structural material for vacuum-forming, thermoforming, and fabrication. Pro-fax film for packaging has sparkling clarity, outstanding toughness, and excellent resistance to permeation.

pro-fax®

CP 59-10

TYPICAL PROPERTIES OF PRO-FAX

Crystalline melting point, °F.	333
Specific gravity	0.901
Mold shrinkage, in./in.	0.015 to 0.020
Water absorption, %	0.03
Heat-distortion temperature (66 p.s.i.), °F.	221
Deformation under 2000-lb. load for 6 hr. at 122°F., %	2.0
Hardness, Rockwell R	93
Impact, Izod, ft.-lbs./in., notched	1
unnotched	>17
Tensile yield stress at 73°F., p.s.i.	4970
at 212°F.	1720
Ultimate elongation at 73°F., %	>220
Dielectric constant	2.0
Power factor	0.0003

HERCULES POWDER COMPANY
INCORPORATED
WILMINGTON 99, DELAWARE

For complete property and use data, or specific informat
on any of the products shown here, call or write:

NONMETALLIC MATERIALS AND FINISHES

PHOTO REPORT:

SPECIAL FELT TREATMENTS

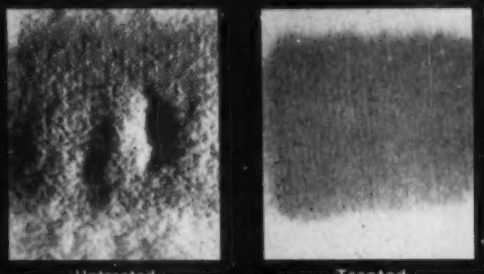
Increase Life, Improve Properties for Seals, Filtering and Cushioning

Never before has FELT been able to provide such a wide range of properties — for such applications as seals, filtering and cushioning! And Felters is continually experimenting with many combinations to provide designers with more and more versatility in felt, including use of the newest synthetics and plastics.

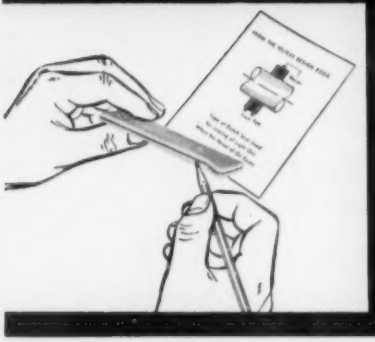
What do you want FELT to do?
Felters has pioneered in producing felts which have unusual properties for special applications.
Let Felters help you make felt do more jobs, more efficiently — with special treated or standard Cut Parts. Specific technical service is available from any Felters office.

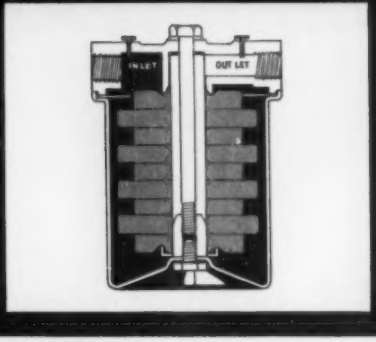
Send for Design Book . . .
for a complete digest of basic data on felt properties and uses.

Felters' Nylon-treated all wool Felt provides extra wear, superior resistance to scuffing, abrasion and friction. Extra strength without increased density. Each fiber encased in protective sheath of nylon. Porosity and resistance of felt unaffected. Wyzenbeck Wear Test of 6,000 strokes on Untreated versus Nylon Resin Treated Swatches demonstrates the difference.



Untreated Treated





For Seals — Felters Dufelt is ideal for use as a seal with light oils, when no head of oil exists. Dufelt incorporates layers of Hycar, sandwiched with standard felts, in a number of different combinations.

Felters' Filtering Felts assure uniform densities for filtering a wide range of liquids and air. Includes oil, latex, cellulose products, gasoline, alcohol and similar media. Capillary value controlled by varying fibre density and grade.

Vibration Isolation and Cushioning can be effectively achieved by using special Unisorb Pad or Unisorb Level-Rite machine mounts. Prevents transmission of vibration to surroundings, improves operation of machine tools.

the **FELTERS** company
259 SOUTH ST., BOSTON 11, MASS.
Pioneer Producers of Felt and Felt Products

Protects your product . . . improves its looks . . . *and handles well in production*

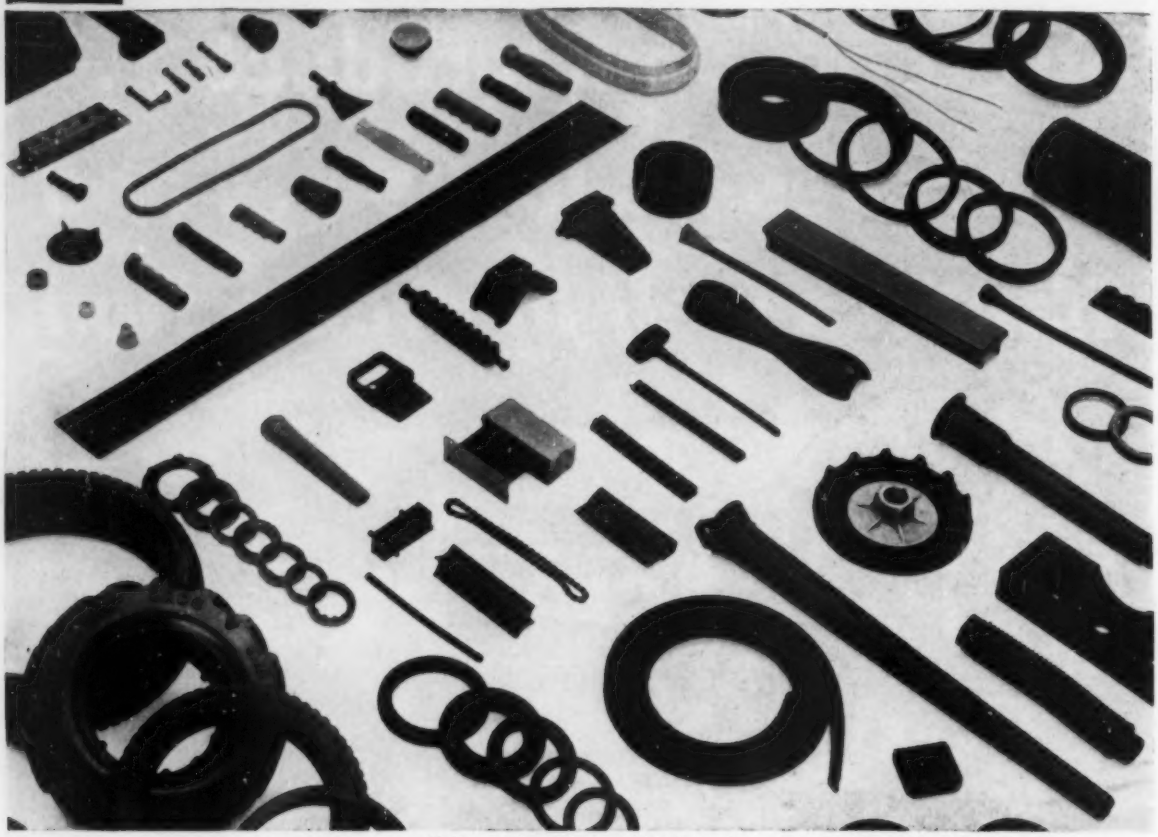
Your product can have extra sales appeal easily and economically with either of these versatile, easy-to-clean finishes in this established top-quality vinyl. *Masland Duran Clad* can be laminated to metal. Even shearing, crimping, punching, drilling won't impair its texture or color. Wide decorative range. *Masland Duran Clad-On* with adhesive coated back for quick, easy application. Many outstanding colors and textures. Helps cut down your finishing costs.

Industrial Products Division
THE MASLAND DURALEATHER CO.
Dept. PE • Philadelphia 34, Pa.

THE MASLAND DURALEATHER CO. Dept. PE
Amber & Willard Sts., Philadelphia 34, Pa.
Please send information and samples of Clad: ☐ *Clad-On:* ☐

Name _____ Title _____
Company _____
Street _____
City _____ Zone ____ State _____

C NONMETALLIC MATERIALS AND FINISHES



Tailor-made rubber and flexible vinyl parts produced through Ohio Rubber "Customeering" for original equipment in every industry.

How OHIO RUBBER fashions more profitable PARTNERSHIPS

An Ohio Rubber "Customeering" engineer may start with your blueprint, but he begins saving you money *after* he checks your performance requirements—what you need, where and how you'll be using your component part.

Your savings start with his recipe for the material which goes into your part. Only the essential properties required for the better performance of *your* product will be included—you will not be buying properties you don't need.

The ORCO engineer's recommendations for feasible design modifications will further help produce a better part, frequently at big savings to you.

Combined with Ohio Rubber's integrated mold and die service, complete facilities for molding, extruding, and bonding to metal, here's a profitable partnership you may want to consider for your custom-made parts of rubber, synthetic rubber, silicone rubber, polyurethane, or flexible vinyl—one that offers all the advantages of single source control and responsibility.

Suggestion: The more complete story behind Ohio Rubber's long-standing and profitable partnerships with leading original equipment manufacturers is more fully told in ORCO Bulletin 715. Write for your free copy today! 9MP1

ORCO THE OHIO RUBBER COMPANY
WILLOUGHBY, OHIO
A DIVISION OF THE EAGLE-PICHER COMPANY

NONMETALLIC MATERIALS AND FINISHES

Why it will pay you to

CONSIDER GLASS

before your products reach the blueprint stage

WHY GLASS?

It's versatile and basic.

And if it is a *Corning* glass, it offers your products these solid benefits:

Permanent finish. Corning glass compositions resist weather, chemical attack, abrasion and high temperatures. Their surfaces stay non-absorbent and non-porous — clean quickly.

Controlled transparency. Corning glasses are uniformly transparent—piece after piece, year after year. Colored or clear—they never lose their original clarity.

Hermetic enclosures can be made in rugged designs from special glasses developed for glass-to-metal fusion sealing.

Electrically conductive coatings. Fired on to glass, they are a very efficient source of radiant energy. They provide uniform heat distribution of a long wave length radiation readily absorbed by most materials.

Durability. Glasses with ingenious balances of mechanical, electrical and chemical properties plus correlation of form and shape insure a durable product.

Heat indifference. Corning glass keeps strength and finish at high temperatures—in some compositions from 900°F. to 1700°F. Heat indifference is furthered by designs that carefully distribute thermal stress.

Electrical stability. Corning glasses have high resistivity, low power losses, low and high dielectric constants, excellent non-tracking properties. They can also be furnished with special characteristics of high dielectric strength.

Chemical inertness. Corning glasses resist most atmospheres and chemicals even at relatively high temperatures—do not pit, scale or rust. They keep their chemical, mechanical and electrical properties indefinitely.

WHICH GLASS?

You can choose from five types of Corning glasses. These fill most needs. But, if you have an unusual application—one that cannot be met by any of the following types—special variations will be suggested.

Borosilicate glasses have high thermal endurance, softening points, chemical resistance, and excellent electrical stability.

High silica glasses have extreme thermal endurance, very high softening point, high chemical resistance, excellent electrical properties, and exceptional transmittance of the ultraviolet or the infrared.

Opal glasses have uniform and well-controlled translucence and good mechanical strength.

Lime glasses have controlled mechanical properties and excellent visual qualities.

Lead glasses have controlled mechanical and electrical properties and high visual quality.

WHERE GLASS?

Because you can get Corning glass in almost any shape or form you wish —because you can be sure of the definite and fine balance of properties required for your specific needs, you can use Corning glass in a wide range of applications. Some of these are:

Ovenware
Coffeemakers
Laboratory ware
Electrical insulation
Gauge glasses
Industrial piping
Range burner plates
Crucibles
Ultraviolet lamps
Thermocouple protecting tubes
Induction furnace linings
Electrical insulation
Lighting ware
Food service dishes
Refrigerator storage dishes
Incandescent lamps and stems
Tumblers
Vacuum bottles
Fluorescent lamps
Tableware
Refrigerator trays
Washer windows
Level vials
Fuses
Lampworked novelties
Bowls for food mixers

FREE BULLETIN

For more complete information on how you can advantageously use glass in your product design, send coupon for Bulletin IZ-1.

It lists specifications of the various types and forms of Corning glasses and tells how our design service can help you.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 51-9 Crystal Street, Corning, N.Y.

Please send me a copy of Bulletin IZ-1, entitled "Designing with Glass for Industrial, Commercial and Consumer Applications."

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

C NONMETALLIC MATERIALS AND FINISHES

how much Dust can a filter collect?

UP TO 99.99%

if it uses WESTERN FELT!

Such efficiency is possible in a Hersey reverse-jet filter with particle size of 5 microns and a pressure drop of ½ inch of water.

Felt can be used to filter solids from solids, solids from liquids, or solids from gases. It is used effectively in fuel filters, air filters, chemical filters, respirators, or dust collectors.

Microscopic barbs on the live fibers of Felt make felt the ideal filtering medium. These scales collect and hold dust particles. They also encourage "build-up" or caking which actually increases filter efficiency. At the same time, their natural interlocking action holds fibers tightly together, through years of flexing.

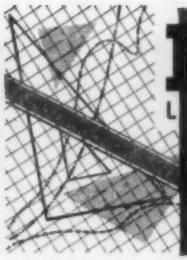
For helpful engineering information on filtration felts, write

WESTERN Felt WORKS

Dept. M
4021-4139 Ogden Ave.
Chicago 23, Ill.

MANUFACTURERS AND CUTTERS OF WOOL FELTS

NONMETALLIC MATERIALS AND FINISHES



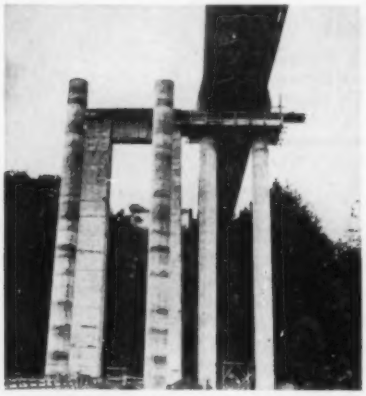
MOLYKOTE® LUBRICANT DESIGN news

GERMAN ENGINEERS USE MOLYKOTE TO SLIDE 944 FOOT BRIDGE 60 FEET

The relocation of a bridge of these dimensions without the use of rollers has not previously been reported. The weight of the bridge was approximately 4,500 tons.

The results of extensive testing at the Bavarian Testing Institute at Nurenberg showed it to be more economical to move this bridge on girders lubricated with MOLYKOTE Type G than on rollers.

When writing refer to Item 503.



This bridge carries traffic of the Munich-Salzburg Highway over the Mangfall Valley.

MOLYKOTE® OPERATES EFFECTIVELY OVER -300°F. TO 750°F. TEMPERATURE RANGE

ATOMIC RADIATION DOES NOT AFFECT MOLYKOTE TYPE Z

Extreme temperatures rule out the use of conventional lubricants. They freeze solid at extremely low temperatures or form objectionable deposits at elevated temperatures.

The missile age has further complicated lubrication problems. Not only must lubricants operate over a wide temperature range, but they must be unaffected by radiation, be capable of functioning in a vacuum, be compatible with liquid oxygen, and have indefinite storage life.

MOLYKOTE Type Z meets all of these requirements and is the only lubricant known to operate over a 1050°F. temperature range (-300° to 750°F.). In inert atmospheres, MOLYKOTE Type Z is unaffected by temperatures as high as 2000°F.

MOLYKOTE assures nearly 100% protection against galling and seizing on all low velocity extreme bearing pressure applications. With MOLYKOTE, the coefficient of friction decreases with increased loads and there is no tendency for it to be wiped away. The coefficient of friction with MOLYKOTE Type Z is .024 at 400,000 psi. MOLYKOTE maintains its effectiveness in the presence of all but a few strong acids. The problem of lubrication where abrasive dust contaminates the atmosphere is greatly reduced by MOLYKOTE dry films. MOLYKOTE Type Z conforms to MIL-M-7866A (ASG). It is the basic ingredient in the many MOLYKOTE types that are available to industry.

When writing refer to Item 501.

NEW MOLYKOTE "WEAR IN" COMPOUND REDUCES SURFACE DAMAGE RESEARCH PROVES

During the critical wear in period, permanent surface damage, variously described as "galling", "scuffing", "scoring", "tearing", "scratching", "excessive abrasion", and "seizing", is an inherent hazard.

Cross section of ground steel surface. (Redrawn to scale.)

When magnified, even highly polished metals show surface irregularities as in the drawing above.

MOLYKOTE "Wear In" Compound was developed as a result of extensive research. It drastically reduces the time necessary to accomplish wear in and eliminates the hazards.

"Wear In" damage requires costly reconditioning of new equipment and the amount of damage left unrepaired has much to do with the useful service life of machinery.

When writing refer to Item 502.

LIFETIME LUBRICATION WITH MOLYKOTE BONDED COATINGS

MOLYKOTE resin bonded lubricant coatings combine all the outstanding characteristics of MOLYKOTE with today's most advanced air-drying and thermosetting resins.

Roller Bearing Company, W. Trenton, N. J., process self-aligning bushings with a MOLYKOTE resin bonded coating. This coating provides lifetime lubrication and protection against corrosion.

MOLYKOTE resin bonded lubricant coatings are an amazing new development in the field of lubrication. They provide bearing surfaces with a wear-resistant film that has a low coefficient of friction. In many cases, the initial treatment is sufficient to lubricate parts for the lifetime of the equipment.

When writing refer to Item 504.

Self-aligning bushing manufactured by Roller Bearing Corporation of America, W. Trenton, N. J.

THE ALPHA-MOLYKOTE CORP.,
Stamford, Conn.
Please send me details on
Item 501 ☐ Item 502 ☐
Item 503 ☐ Item 504 ☐
Name .....
Company .....
Address .....
City .....
State .....

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE — OR WRITE FOR COPY

Address your letter to The Alpha-Molykote Corp., 65 Harvard Ave., Stamford, "Research City", Conn. Phone: FIreside 8-3724.

THE ALPHA-MOLYKOTE CORPORATION
BREAKING LUBRICATION BARRIERS
. . . THROUGH RESEARCH

NONMETALLIC MATERIALS AND FINISHES

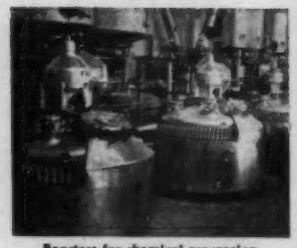
This is PORCELAIN

CHEMICAL RESISTANCE

Resistant to attack by chemicals, gases, water and other corrosives. Acid-resistant grades resistant to all acids except hydrofluoric. All grades immune to organic solvents and cold or warm mildly alkaline solutions.

Representative Applications

Reactors • Chemical Piping • Storage Tanks • Water Heaters • Pump Bearings • Bearing Seals • Evaporators • Juice Extractors • Water Meters • Plumbing Fixtures • Home Laundry Equipment • Dishwashers



Reactors for chemical processing.

ABRASION RESISTANCE

One of hardest known finishes for resisting abrasion. Hardness ranges from 3½ to 6 on Moh's scale. High surface hardness, resistance to crushing, very low coefficient of friction.

Representative Applications

Conveyor Buckets and Flights • Pump Cylinders • Screw Conveyors • Petroleum Bubble Caps • Wood Chipper Plates . Chutes for Coal, Grain and Packages • Strainer Baskets • Appliance Work Surfaces

Conveyor buckets for handling rock salt.

HIGH HEAT RESISTANCE

Special ceramic coatings withstand continuous service temperatures above 1800°F, regular types to 1100°F. Excellent thermal shock resistance, in some cases as much as an 800°F sudden temperature drop.

Representative Applications

Jet, Rocket, Piston-Engine Exhaust Systems • Kitchen Ranges • Incinerators • Submarine Snorkels • Chimney Caps • Fireplaces • Flue Liners • Space Heaters

Combustion chamber for space heater.

ATMOSPHERIC CONDITIONS

Industrial atmospheres, salt air, wind-driven gases and smoke are combatted successfully by Porcelain Enamel. Neither color nor finish is adversely affected by heat, cold, rain, snow, ice and sunlight.

Representative Applications

Outdoor Signs • Panels, Mullions, Coping, Fascia and Similar Architectural Members • Industrial Buildings • Gasoline Pump Housings • Lighting Fixtures • Downspouts • Roofs • Billboard Components • Marquees

Outdoor architectural applications.

COLORS AND TEXTURES

Most all colors of the visible spectrum in solid or variegated appearances. Corrugated, embossed and other textured metals may be used. Pebbled, stippled and speckled textures ranging from high gloss to full matte.

Representative Applications

Range, Refrigerator, Washer and Dryer Components • Architectural Panels • Cooking Ware • Ship Bulkheads • Vending Machines • Toasters • Art Ware • Lamp Bases • Space Heater Cabinets

Broad variety of textures and colors.

ENAMEL

A HIGHLY VERSATILE PRODUCT COMBINING HARDNESS OF GLASS AND STRENGTH OF STEEL

New Technical Developments Make It An Even More Functional Design Material

Technical developments such as those outlined here have broadened substantially the range of applications where Porcelain Enamel can serve. Today Porcelain Enamel is no single material, but a whole class or family of materials embracing thousands of separate formulations.

Improvements in Frit Formulations

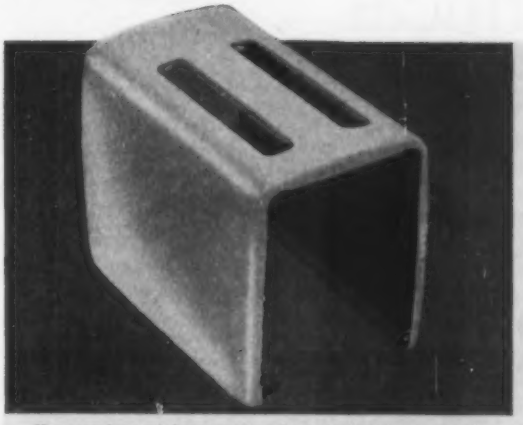
Some of the most dramatic technical advances have resulted from improvements in formulations for frit, the basic raw material in Porcelain Enamel. Frit now is a custom-designed material which is compounded specifically to produce optimum characteristics for every Porcelain Enamel application.

Thinner Coatings

Reduction in over-all thickness produces a significant lessening of the danger of mechanical damage and also improves resistance to thermal shock. The result is an economical product of greater strength and durability—with no sacrifice of hardness, corrosion resistance, gloss, color or other characteristics.

Lower Firing Temperatures

Special frits, together with refinements in enameling techniques, have allowed enameling temperatures to be reduced by as much as 200°F. Now more complex steel shapes can be fired without distortion. Also, with many products extra bracing and other special designs formerly required are no longer necessary.



More complex steel shapes, such as this toaster housing, now can be Porcelain Enameled due to lower firing temperatures.

Improved frit formulations have done much to broaden applications for Porcelain Enamel.

NOW AVAILABLE! NEW PORCELAIN ENAMEL ENGINEERING DATA FILE

Contains much technical material never before available. Return this coupon for your copy.

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Washington 6, D. C.

☐ Please send a copy of the new Engineering Data File.

☐ Please send information about possible application of Porcelain Enamel

to _____
(type of product)

Name _____ Title _____

Company _____

Address _____

City _____ State _____
Please Print

WRITE 147 ON READER SERVICE CARD

When the application is critical look to Rogers

All Rogers materials were formulated to meet requirements that demand something "extra" in ability to take punishment — be it shock, heat, corrosive chemical action, pressure or the special circumstances of space-age applications.

ELECTRONIC AND ELECTRICAL INSULATION

PLASTICS MOLDING COMPOUNDS
- RX-Type Impact Phenolics
- RX-Type Diallyl Phthalates
- RM & RA-Type Phenolic Molding Boards

REINFORCED FLUOROCARBONS
- Duroid 5600 Series — Ceramic Fiber-Reinforced Teflon
- Duroid 5800 Series — Glass Fiber-Reinforced Teflon

FIBROUS SHEET MATERIALS
- Duroid-Type Specialty Grades
- RL-Type Asbestos-Reinforced High Temperature Phenolic Laminates
- Motor Slot Cell Papers
- Transformer Insulation

PRINTED CIRCUITS
- Molded Circuits for Switches, Timing Devices and Heavy Current-Carrying Parts
- Copper-Clad Duroid 5870

ELASTOMERIC COMPOUNDS

GASKETING AND SEALING

Duroid 900 Cellulose-reinforced Buna-N
Duroid 3102 Asbestos-reinforced Neoprene
Duroid 3200 Asbestos-reinforced Buna-N
Duroid 3300 Asbestos-reinforced GR-S
Duroid 3400 Asbestos-reinforced Viton A
Duroid 5600 Ceramic fiber-reinforced Teflon
Silicone Rubbers to Specification
Viton A Rubbers to Specification

SPECIALIZED APPLICATIONS

Thermal Insulation
Cellular Rubber Floats
Matrix Materials for Printing
Shoe Materials for Midsoles and Innersoles

For a more detailed but still quickly-digested round-up of our materials, write for the Rogers EXTRA, Dept. HB

ROGERS CORPORATION
ROGERS, CONNECTICUT

Taylor Laminated Plastics and Vulcanized Fibre

Basic materials for electrical, electronic and mechanical applications

More than 50 grades to meet any requirement

Take your pick from paper, cotton cloth, nylon, asbestos, glass cloth or other base material impregnated with phenolic, melamine, silicone or epoxy resins and formed into sheets, rods and tubes under heat and pressure.

There is one grade that will fit your exact requirements—whether you need good electrical insulation, great structural strength, resistance to chemical reaction, resistance to heat and flame, ease of fabrication, or a combination of these characteristics.

Phenolic Laminates. Thermosetting type. Paper, cotton fabric or mat, asbestos, glass cloth or nylon bases impregnated with phenol formaldehyde type resins. Provide dependable electrical insulation, have high dielectric and mechanical strength. Some grades are excellent basic materials for gears, cams, pinions, bearings and other mechanical applications. Asbestos grades are qualified as Class B insulation; others meet Class A requirements.

Melamine Laminates. Thermosetting type. Glass cloth or cotton fabric impregnated with melamine formaldehyde resin. These laminates have superior mechanical strength and are especially desirable for their arc resistant qualities. Good flame and heat resistance and good resistance to the corrosive effects of alkalis and most common solvents are other favorable characteristics. Classified as Class B insulation.

Silicone Laminates. Thermosetting type. Continuous filament woven glass fabric impregnated with a silicone resin. These laminates combine high heat resistance (up to 500°F., continuous) with excellent electrical and mechanical properties. Have low power factor and moisture absorption rate; very high insulation resistance and high arc resistance; excellent dimensional stability and high tensile, flexural and impact strength. Classified as Class H insulation.

Epoxy Laminates. Thermosetting type. Continuous filament woven glass fabric or paper impregnated with epoxy resin. Combine low moisture absorption with excellent chemical resistance and high mechanical strength. Characterized by good dielectric strength, low dielectric losses, and high insulation resistance even after being subjected to severe humidity conditions. Can be copper clad for production of high fidelity printed circuits.

Copper-Clad Laminates. Offer a combination of high-purity copper on superior base materials to produce printed circuits of consistently high quality. Taylor copper-clad laminates are available in several phenolic resin, paper base grades, in epoxy resin, paper or glass cloth base grades, and in specially formulated grades to meet specific requirements. All grades meet or exceed military and NEMA standards. The copper cladding is 99.5% pure and free of pinholes, pits and lead inclusions—has a high-quality finish that accepts all acid resists. All Taylor copper-clad laminates are supplied with 1, 2 or 3-oz. copper on one or both sides.

Flame-Resistant Laminates. Flame-retardant paper base laminates made with special phenolic resin. Have excellent moisture resistance, high electrical resistance and good mechanical properties. Offer low dielectric losses. Meet tentative Underwriters' Laboratory requirements for flame retardance.

TAYLOR VULCANIZED FIBRE

Taylor Vulcanized Fibre is a hard, dense material with excellent physical, mechanical and electrical properties. It is tough and resilient; has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline; can be machined, stamped, punched and formed; is attractive in appearance, light in weight. Available in a number of different grades, in sheets, rolls and turned rods: commercial, bone, electrical, trunk, superwhite, built-up, abrasive, flexible, track.

TAYLOR INSULATION

This material, sometimes called fishpaper, is a highly specialized type of electrical insulation. It has high dielectric strength, is tough and abrasion resistant, has excellent bending properties.

ENGINEERING AND FABRICATING SERVICES

New applications for Taylor materials are constantly being developed by design and production engineers in the Taylor plants. These men are available for consultation. Their experience and counsel can help you in the development of your product. Taylor's fabricating division can economically produce parts from any of the above materials. Consult us for complete details on either one or both of these Taylor services. Technical engineering data on all these products available upon request. Write Taylor Fibre Co., Norristown 39, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

WRITE 149 ON READER SERVICE CARD 149

Aico
PRECISION MOLDED
Plastics

coordinated facilities for molding all types of plastics under one roof **saves time, cuts costs**

AICO is a veritable one-stop shopping spot for all your molded plastics needs. At AICO you will find skilled technicians whose long and specialized experience keeps each job "on schedule" every step of the way . . . from design, through mold building, molding, final inspection and delivery. Regardless of molding material, molding method required or quantities involved . . . AICO is equipped to do the entire job. Under one roof, at AICO, you will find completely coordinated facilities to assure fast, economical production of all your custom molded plastics.

AMERICAN INSULATOR CORPORATION

NEW FREEDOM, PENNSYLVANIA

AICO'S COMPLETE PLASTICS MOLDING SERVICE INCLUDES:

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- MOLD BUILDING
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FREE TO HELP YOU MAKE BETTER USE OF PLASTICS

AICO PLASTICS DESIGNER'S HANDBOOK

Tells and illustrates how low unit cost can be achieved through proper plastics design.

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Tells molding material best suited for your product . . . tells how it should be molded.

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Tells how to select a fully-equipped molder to do your job . . . shows how to avoid split responsibilities.

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catalogs and bulletins . . . . . continued

(C-84) **Steel-backed Rubber Lining**—Brochure, 4 pp. Describes construction materials and pressing operation. Used as structural member for sluices, chutes, hoppers, and others. The Goodyear Tire & Rubber Co, Industrial Products Div, Akron 16, Ohio.

(C-85) **Custom Molded Rubber Parts**—Brochure, 8 pp. Describes various compounds, mold making and illustrates typical rubber parts. Includes information on rubber to metal bonding process. Minnesota Rubber Co, 3630 Wooddale Ave, Minneapolis, Minn.

(C-86) **Tube and Pipe Insulation**—Brochure, 4 pp. Characteristics of closed-cell neoprene pipe insulation. Includes ASTM specified tests for determining materials performance. Presstite Div, American Marietta, 39th & Chouteau, St Louis, Mo.

(C-87) **Thermoplastic Resin**—Bulletin, 24 pp. Describes processing, physical and chemical resistance data and aging tests on high impact thermoplastic resin used for calendering, extruding, injection and compression molding and vacuum forming. Marbon Chemical Div, Borg-Warner Corp, PO Box 68, Washington, W Va.

(C-88) **Expandable Polystyrene**—Bulletin, 4 pp. Shows application of foamed plastic material in packaging. Illustrations, chemical and physical properties, ratios and charts. Koppers Co, Inc, Plastics Div, Koppers Bldg, Pittsburgh, Pa.

(C-89) **Glass Laminates**—Bulletin, 4 pp. Physical and electrical properties of glass reinforced polyester electrical insulation laminates. The Glastic Corp, 4321 Glenridge Rd, Cleveland 21, Ohio.

(C-90) **Plastic Pipe, Fittings and Valves**—Catalog, 8 pp. Lists recommended uses, installation procedures, physical properties. Suitable for threaded, solvent welded and flanged piping applications in variety of corrosion services. B F Goodrich Industrial Products Co, Marietta, Ohio.

(C-91) **Plastisol Compounds**—Brochure, 4 pp. Describes materials, applications, construction features and color coding of various products utilizing plastisol. Minnesota Rubber Co, 3630 Wooddale Ave, Minneapolis, Minn.

(C-92) **Polystyrene Applications**—Brochure, 12 pp. Describes the advantages, physical and chemical properties, applications, grades and techniques of manufacture. Foster Grant Co, Inc, Leominster, Mass.

(C-93) **Laminated Plastics**—Catalog, 28 pp. Information on laminated plastic sheets, rods, tubes; includes molded laminated and molded macerated properties and characteristics. Synthane Corp, Oaks, Pa.

(C-94) **Nylon Stock Shapes**—Brochure, 4 pp. Presents property and application advantages of molybdenum disulphide filled nylon. Lists dimensions of rod, strip, tubing and other forms. The Polymer Corp of Pennsylvania, 2120 Fairmont Ave, Reading, Pa.

WRITE 150 ON READER SERVICE CARD

COATING	FABRIC SUBSTRATES				
	COTTON	NYLON	"DACRON"*	GLASS	"TEFLON"*
NEOPRENE	●	●		●	
BUNA-N	●	●		●	
"FO"†	●	●			
BUTYL	●	●			
"HYPALON"*		●	●	●	
ACRYLIC			●	●	
SILICONE			●	●	●
"VITON"*			●	●	●

*Registered Du Pont trademark
†A Du Pont trade name

At Du Pont special coatings are combined with selected fabrics to produce "Fairprene" having the advantages of both. Tabulated above are many of the combinations possible. Fabric can have balanced coating on each side; can have one side bare; or more or less heavily coated than the other; or a different coating on each side. "Fairprene" can have more than one layer of fabric enclosed or can have compound between layers of fabric. Thus "Fairprene" is remarkably versatile material tailor-made for an extraordinary range of applications.

These elastomer-fabric combinations of Fairprene® form design materials of marvelous versatility

Exciting new design materials with an outstanding range of capabilities are created by the exclusive calendering-coating process that forms "Fairprene". Using this process, Du Pont creates many materials from elastomer and fabric with many variations in their chemical and physical properties. Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products or improving present ones. Mail the coupon or write E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division PE-DD, Wilmington 98, Delaware, for complete information.

INDUSTRIAL COATED FABRICS
SHEET STOCKS • CEMENTS

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

Can your product be added to this growing list of applications for Du Pont "Fairprene"** coated fabrics?

- Aileron Seals
- Airforms
- Air Seals
- Air Shelters
- Aprons
- Balloons
- Bearing Seals
- Boots and Bellows
- Cable Wrap
- Carburetor Diaphragms
- Compressor Diaphragms
- Condenser Seals
- Control Device Diaphragms
- Dielectric Sealing Vent
- Distributor Diaphragms
- Draw Sheets
- Engine Baffles
- Fire Curtains
- Flexible Ducting
- Flow Meter Diaphragms
- Fuel Bags
- Fuel Cell Seals
- Fuel Economizer Diaphragms
- Fuel Injection Unit Diaphragms
- Fuel Pump Diaphragms
- Foundation Blankets
- Gaskets
- Gouge Strips
- Instrument Diaphragms
- Landing Mats
- Laundry Roll Covers
- Lightweight Belting
- Meter Bellows
- Meter Diaphragms
- Microphone Covers
- Missile Blast-Deflection Curtains
- Modulator Diaphragms
- Packings
- Propeller De-icers
- Protective Clothing
- Pump Cups
- Pump Diaphragms
- Radar Antenna
- Radomes
- Regulator Diaphragms
- Tarpaulins . . . Tents
- Top Sheets
- Vacuum Device Diaphragms
- Vacuum Molding Bags
- Water Bags

**"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.

E. I. du Pont de Nemours & Co. (Inc.)
Fabrics Division PE-DD, Wilmington 98, Delaware

Please send me further information about coated fabrics. I am interested in using a coated fabric for _____

Name _____ Title _____

Firm _____

Address _____

City _____ Zone _____ State _____

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Standard and Custom Orders

Lefco Plastics offers you a ready source of volume production—or research, development—of a complete group of fluorocarbons and other specialized plastics. Fluorocarbons, with their unique combination of electrical, chemical, and frictionless properties over wide temperature ranges open up new performance advantages. Your inquiry invited; Write for literature.

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12177 Montague St., Pacoima, Calif.

a subsidiary of
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SMALL PRODUCTION RUNS OF PLASTIC PARTS AT LOW COST

Regardless of the size, shape or quantity requirements of your product, we can provide pilot or test market runs at very economical cost. Experienced craftsmen and special facilities also available to work out your design and production problems. Write us today! All inquiries receive our prompt and interested attention.

custom molders of the unusual

STANDARD PLASTICS Company
INCORPORATED

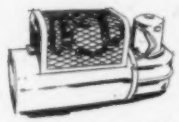
NEW YORK OFFICE 303 FIFTH AVENUE TEL. MURRAY HILL 6-0327
MAIN OFFICE AND FACTORY 64 WATER STREET TEL. 1-1940
ATTLEBORO, MASS.

When you're choosing a protective coating...
HOW HOT IS YOUR HOT?

A Nose Cone Gets Hot

When conventional organic finishes were used in Chrysler Redstone Missile tests, they ignited and disintegrated under simulated re-entry conditions. Sicon survived because it possessed the inherent heat resistance to meet performance requirements. This has been confirmed in large scale tests and actual missile firings.

A Truck Heater Gets Hot



A porcelain type coating used on a truck heater failed because it could not stand the thermal shock of rapid heating and cooling. The same heating (550°-600°F.) and cooling left Sicon's film integrity unaffected.

A Tractor Engine Gets Hot

A farm equipment manufacturer used a bright organic red color on their standard equipment. The coating on the engine parts, which were subjected to high temperature, quickly decomposed. Midland engineers developed a matching bright Sicon Red which retained its color and gloss and protected the hot spots on the engine.

How HOT is your HOT?

Sicon possesses the flexibility of ordinary organic finishes and the heat resistance of ceramic coatings—up to 1000°F. in black or Aluminum; up to 550°-600°F. in decorative colors. Upon inquiry a sample Sicon formulation for testing your "hot" requirements will be prepared at no obligation. Send details of your "hot spot" problem today to Dept. G-31-59.

Sicon®
HEAT RESISTANT FINISH
A Silicone Product of

MIDLAND
INDUSTRIAL FINISHES COMPANY
WAUKEGAN • ILLINOIS
ENAMELS • SYNTHETICS • LACQUERS • VARNISHES

WRITE 607 ON READER SERVICE CARD

catalogs and bulletins.....continued

(C-95) Hardboards—Catalog, 8 pp. Interior and exterior applications in concrete form construction, table of properties, installation photographs and drawings. Masonite Corp, 111 W Washington St, Chicago 2, Ill.

(C-96) Elastomer Packing Material—Brochure, 4 pp. Chemical, physical and electrical properties of elastic material available in hardness values from 60 to 96 durometer. Albert Trostel Packings, Ltd, Lake Geneva, Wisc.

(C-97) Coating Processes—Catalog, 31 pp. Lists various corrosion resisting phosphate and conversion coatings for preparing metals for paint. Also rust removers, metal conditioners, steam processes, acid and alkaline cleaning compounds. Describes materials, methods of application and required equipment. Neilson Chemical Co, 2312 Gainsboro, Detroit 20, Mich.

(C-98) Resin Molding Compound—Bulletin, 25 pp. Describes use of allylic plastic material in dry form for compression and transfer molding. Chemicals & Plastics Div, Food Machinery & Chemical Corp, 161 E 42nd St, NY 17, NY.

(C-99) Liquid Nitrogen—Bulletin, 20 pp. Properties, design factors, thermodynamic data and safety considerations together with charts and tables. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY 17, NY.

(C-100) Cellulose Acetate Molding Compound—Bulletin, 16 pp. Describes properties, molding and fabricating techniques for all acetate formulations. Celanese Corp of America, Plastics Div, 744 Broad St, Newark, NJ.

(C-101) Die Steel Finishes—Brochure, 4 pp. Applications, illustrations, description and economics of finish for square and flat bar forms of tool steels. Crucible Steel Co of America, PO Box 2518, Pittsburgh 30, Pa.

(C-102) Metal and Plastic-faced Laminates—Brochure, 6 pp. Describes special features of laminated material, its application in the industrial and architectural fields, plus mechanical properties. United States Plywood Corp, 55 W 44 St, NY, NY.

(C-103) Industrial Rubber Products—Catalog, 35 pp. Contains specifications, standard lengths, selection guide and accessories for v-belting, hoses, couplings, sheaves, and other rubber products. The Gates Rubber Co, 999 S Broadway, Denver, Colo.

(C-104) Thermoplastic Sheets—Brochure, 8 pp. Lists sizes available in laminated, calendered or extruded sheet form. Describes basic types and their applications. Plastics Div, Seiberling Rubber Co, Newcomerstown, Ohio.

(C-105) Lubricants—Catalog, 32 pp. Outlines lubrication practices and principal uses of fluid and grease types. Also lists properties and suppliers. Lubriplate Div, Fiske Bros Refining Co, 129 Lockwood St, Newark 5, NJ.

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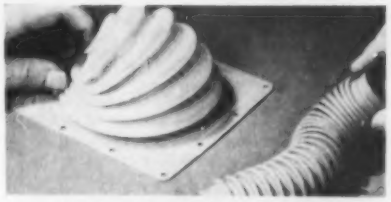

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(C-106) Thermoplastic Resins—Bulletin, 10 pp. Describes applications in housewares, toys, textiles and industry; properties and characteristics of typical products. Celanese Corp of America, Plastics Div, 744 Broad St, Newark, NJ.

(C-107) Plastic Extrusions—Brochure, 6 pp. Description of laboratory, engineering and manufacturing capacities and procedures available for original thermoplastic parts. The Conneaut Rubber and Plastics Co, Commerce St, PO Box 257, Conneaut, Ohio.

(C-108) Synthetic Rubber Products—Catalog, 19 pp. Describes raw materials, basic types of synthetic rubber; covers recommended uses and specifications of molded and extruded shapes, sheet and roll goods, lathe cut seals and others. Acadia Synthetic Products Div, Western Felt Works, 4115 Ogden Ave, Chicago, Ill.

(C-109) Reinforced Fiberglass—Catalog, 20 pp. Describes facilities, type of molding, technical data, glossary of fiberglass terms, comparable chart of physical properties, and suggestions in polyester glass laminates. The General Tire & Rubber Co, 1700 Factory Ave, Marion, Ind.

(C-110) Thermoplastic Extrusions — Catalog, 4 pp. Brief description of applications and engineering data. Also information regarding coating and instrumentation tubing. Pyramid Plastics, Inc, 554 W Polk, Chicago, Ill.

(C-111) Polyester Resins—Bulletin, 4 pp. Gives properties, production methods, characteristics and applications of liquids with adjustable viscosities. Celanese Corp of America, Plastics Div, 744 Broad St, Newark, NJ.

(C-112) Urethane Foams—Brochure, 12 pp. Contains properties, characteristics, comparative test data and application information on flexible polyether and polyester urethane foams. Illustrated. Mobay Chemical Co, 1815 Washington Rd, Pittsburgh 34, Pa.

(C-113) Molded Rubber Parts—Bulletin, 4 pp. Gives design data, services, facilities and illustrates typical products. E F Houghton & Co, 303 W Lehigh Ave, Philadelphia, Pa.

(C-114) Silicone Sponge Rubber—Bulletin, 2 pp. Describes molded and extruded shapes, uses, specifications and typical properties. Lists sheets available from stock and ordering information. The Connecticut Hard Rubber Co, 407 East St, New Haven, Conn.

(C-115) Electroplating Material—Bulletin, 4 pp. Soluble gold complex for electroplating. Describes methods of operation and control. Technic Inc, 39 Snow St, Providence, R I.

(C-116) Vacuum Forming Plastic — Brochure, 6 pp. Describes physical, chemical and electrical properties. Shows uses, various textures and colors. O'Sullivan Rubber Corp, PO Box 603, Winchester, Va.

(C-117) Silicone Fluids—Brochure, 8 pp. Describes their properties and how they are utilized in damping, springing, coupling and other mechanical applications. Illustrated case histories. Dow Corning Corp, Midland, Mich.

(C-118) Insulating Materials—Catalog, 40 pp. Describes properties, engineering values and applications of fibre boards, laminated plastics, and others. Spaulding Fibre Co, Inc, 310 Wheeler St, Tonawanda, NY.

(C-119) Vinyl Plastisols—Brochure, 14 pp. Provides chemical analysis and describes various methods of application and molding, with end uses illustrated. Chemical Products Corp, King Phillip Rd, East Providence, RI.

(C-120) Teflon O-rings—Bulletin, 6 pp. Gives comparison to rubber as an o-ring material; also shows applications, squeeze and groove design, and other engineering information. Chicago Gasket Co, 1271 W North Ave, Chicago, Ill.

(C-121) Tapes—Catalog, 32 pp. Contains temperature limit and selection charts, typical applications, physical properties and electrical characteristics of various tape materials and products. Minnesota Mining & Mfg. Co, 900 Bush Ave, St Paul, Minn.

(C-122) Heating Element Materials—Brochure, 4 pp. Describes construction and applications; gives information on neoprene rubber, silicone rubber and various reinforced plastic insulations. Safeway Heat Elements, Inc, Newfield St, Middletown, Conn.

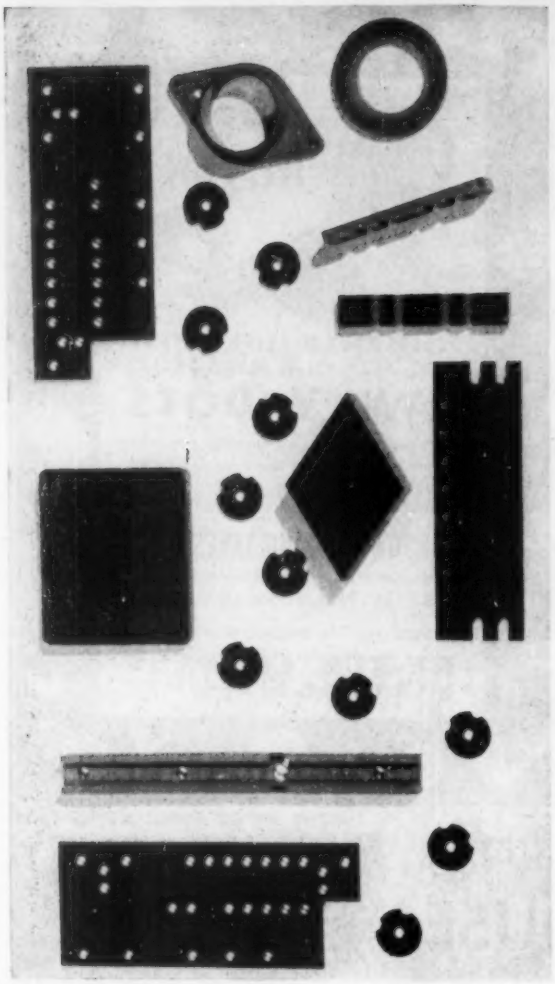
(C-123) Finishes for Aluminum—Brochure, 48 pp. Discussion of mechanical, chemical, electrochemical, electroplated, painted, lacquered, and enameled finishes for aluminum; results expected, characteristics, techniques. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburg, 19, Pa.

(C-124) Rayon, Cotton and Hair Finishes —Bulletin, 9 pp. Gives specifications, uses, selection data and methods of application. Also contains properties chart and listing of facilities. Cellusuede Products, Inc, 500 N Madison St, Rockford, Ill.

(C-125) Tapes and Adhesives—Catalog, 12 pp. Listing of pressure-sensitive tapes, industrial adhesives and refinishing supplies by description, features, properties, government specifications and application. Also contains comparable products listing. Permacel-LePage's Inc, U S Highway 1, New Brunswick, NJ.

(C-126) Textured Vinyl Coating — Brochure, 4 pp. Describes colors and texture of vinyl coating which can be sprayed. For application in product finishing. Metal & Thermit Corp, Rahway, NJ.

(C-127) Industrial Plastics—Catalog, 16 pp. Describes chemical and physical properties, compounding, materials, testing procedures and applications. The Stanley Chemical Co, Subsidiary of The Stanley Works, 401 Berlin St, East Berlin, Conn.



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ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16" thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

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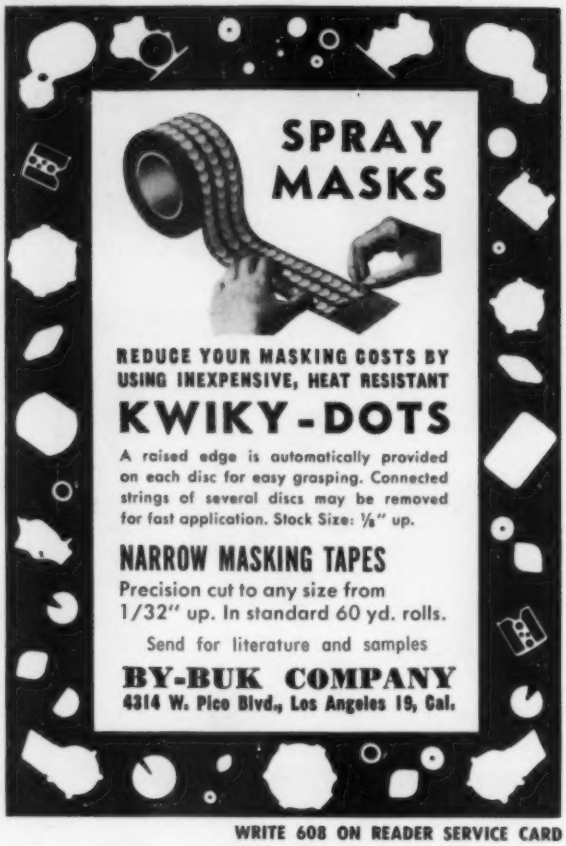
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(C-128) Extruded and Coated Tubings—Catalog, 22 pp. Describes construction, characteristics of plastic and coated electrical insulation tubing; gives sizes, grades and types; lists engineering data and test results; provides ordering information. William Brand & Co, Inc, North & Valley Sts, Willimantic, Conn.

(C-129) Phenolic Resin—Brochure, 6 pp. Properties, characteristics and compatibility of phenolic resin in formulations for furniture, aluminum and spar finishes. Allied Chemical Corp, Plastics & Coal Chemicals Div, 40 Rector St, NY 6, NY.

(C-130) Glass and Plastic Parts—Brochure, 28 pp. Covers wide range of custom parts for OEM flexibility and diversified manufacturing capabilities; produced by molding, grinding and polishing, sealing and other processes for industrial, electronic and commercial applications. Lancaster Glass Corp, Lancaster, Ohio.

(C-131) Silicones—Catalog, 16 pp. Illustrated guide to silicone products and their major applications. Describes fluids, greases, compounds resins, rubber, electrical insulation, and others. Dow Corning Corp, Midland, Mich.

(C-132) Plastic Knobs—Catalog, 8 pp. Contains dimensional drawings, photographs and optional features of standard line. Color data and sales information included. Waterbury Companies, Inc, 835 S Main, Waterbury, Conn.

(C-133) Plastic Bearing Retainers—Catalog, 6 pp. Gives construction data, installation recommendations, load capacity and specifications for needle thrust bearings with fiber glass filled nylon retainers in bore sizes $\frac{3}{8}$ in. to 3 in. The Torrington Co, 59 Field St, Torrington, Conn.

(C-134) Insulating Epoxy Resins—Brochure, 6 pp. Gives selection data, description of heat and room curing systems, physical and electrical properties, viscosity characteristics of resins. Minnesota Mining and Mfg Co, 900 Bush Ave, St Paul, Minn.

(C-135) Polyester Resins—Brochure, 12 pp. Describes resins and uses in reinforced plastic products. Gives laminating, molding, casting, encapsulating and surfacing applications. Reichhold Chemicals, Inc, White Plains, NY.

(C-136) Silicone Rubber Tape—Bulletin, 8 pp. Describes the qualities of silicone rubber and development process. Gives application information and prices. Moxness Products, Inc, 1914 Indiana St, Racine, Wis.

(C-137) Plastic Wire and Cable—Catalog, 6 pp. Describes use of polyvinyl chloride, polyethylene nylon and synthetic rubber in appliance wire, aircraft and military hook-up wires, coaxial cables, and others. Gives material thicknesses, voltage and temperature ratings. William Brand & Co, Inc, North & Valley Sts, Willimantic, Conn.

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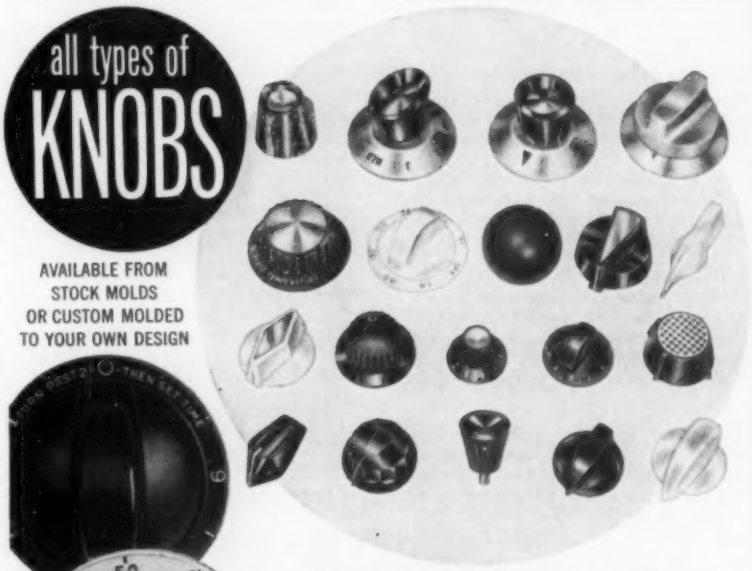

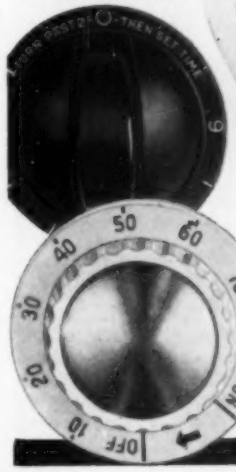

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(C-138) **Resins**—Brochure, 19 pp. Lists the properties, fabricating techniques and applications of fluorocarbon, nylon, polyethylene and acrylic resins. Includes charts and tables of comparative characteristics, chemical, mechanical, electrical, optical and other properties. E I du Pont de Nemours & Co, Polychemicals Dept, Wilmington 98, Del.

(C-139) **Liquid Urethane**—Brochure, 6 pp. Offers engineering data on physical properties, applications and casting technique. Includes comparison chart, bonding and design suggestions. Acushnet Process Co, Belleville Ave PO Box 916, New Bedford, Mass.

(C-140) **Solid Film Dry Lubricant**—Brochure, 2 pp. Contains description of product, results of application and cost saving features. Aviation Lubricants Co, Inc, 2361 India St, PO Box 1607, San Diego, Calif.

(C-141) **Electrical Ceramics**—Bulletin, 4 pp. Contains mechanical and electrical properties of standard grades and recommended applications. General Ceramics Corp, Crows Mill Rd, Keasbey, NJ.

(C-142) **Plastic Knobs**—Catalog, 16 pp. Gives dimensions, operational standards, plastic materials and selection information for line of control balls, instrument knobs, dial assemblies, and others. Kurz-Kasch Inc, Standard Parts Div, 1421 S Broadway, Dayton 1, Ohio.

(C-143) **Urethane Elastomers**—Brochure, 12 pp. Thermal and electrical properties of urethane elastomers for such applications as gears, motor mounts, diaphragms, pulleys, drive belts and vibration dampening components. Mobay Chemical Co, 1815 Washington Rd, Pittsburgh 34, Pa.

(C-144) **Vinyl Plastic Cable Jacket**-Catalog, 8 pp. Specially extruded plastic beading is electronically welded to both edges of a flat tape, jacketed around the conductors, and tightly closed to form an electronic cable. Gives materials, thicknesses, color coding, military specification numbers, and data on cable making machinery. The Zippertubing Co, 752 S San Pedro St, Los Angeles 14, Calif.

(C-145) **Plastic Component**—Catalog, 16 pp. Describes plastics used in piping systems; installation and coupling methods, standards, temperature and operating pressure charts. Chemetrol Corp, 10872 Stanford Ave, Lynwood, Calif.

(C-146) **Mechanical Leather Packings** — Catalog, 57 pp. Covers applications of variety of shapes used to seal air, water, gases and hydraulic fluids. Gives design suggestions. C W Marsh Co, 45 Hudson St, Muskegon, Mich.

(C-147) **Rubber Linings**—Catalog, 12 pp. Specification charts with sample problem solutions, application and installation guides. Used for protection against corrosion, contamination and abrasion. Includes selection aids and photographs. Raybestos-Manhattan Inc, Passaic, NJ.

(C-148) **Rubber Products**—Brochure, 33 pp. Contains selection data, mold designing techniques, and glossary of rubber terms. Also, lists production facilities for seals, diaphragms and o-rings. Acushnet Process Co, Belleville Ave, PO Box 916, New Bedford, Mass.

(C-149) **Urethane Foams**—Brochure, 12 pp. Illustrates and describes practical commercial applications for urethane foam cushioning, insulating and packaging materials. Mobay Chemical Co, 1815 Washington Rd, Pittsburgh 34, Pa.

(C-150) **Designing With Plastics**—Catalog, 592 pp. Contains application design information for plastic materials. Typical uses, fabrication, thermal, physical and chemical properties, operational and dimensional considerations are discussed. E I du Pont de Nemours & Co, Polychemicals Dept, Wilmington 98, Del.

(C-151) **Plastic Materials**—Catalog, 8 pp. Lists the physical, electrical and chemical properties of thermosetting molding compounds, fire retardant laminating resins and phenolic bonding resins. The primary advantages, uses and design factors are also given. Durez Plastics Div, Hooker Chemical Corp, 1514 Walck Rd, North Tonawanda, NY.

(C-152) **Heat Shield**—Bulletin, 5 pp. Ablation heat shield of reinforced plastic for rocket nozzles, blast tubes, and other applications. Contains photographs and application data. H I Thompson Fiber Glass Co, 1733 Cordova St, Los Angeles, Calif.

catalogs and bulletins.....continued

(C-153) Styrene Formulations and Granulations—Brochure, 6 pp. Comparative properties chart of styrene molding and extrusion compounds. ASTM test methods, values and applications are also covered. Catalin Corp of America, One Park Ave, NY, NY.

(C-154) Thermoplastic Sheet and Film—Bulletin, 6 pp. Describes fabrication characteristics, typical applications, thicknesses, finishes and dimensional stability of extruded thermoplastic sheet and film. Campco Div, Chicago Molded Products Corp, 2717 N Normandy Ave, Chicago 35, Ill.

(C-155) Powder and Grease Lubricants—Bulletin, 4 pp. Contains charts and tables of common materials, application methods and selection factors. Gives thermal and chemical properties of the basic lubricating ingredient. The Alpha-Molykote Corp, 68 Harvard Ave, Stamford, Conn.

(C-156) Silicone Resins—Brochure, 16 pp. Describes resistance of silicone insulation to high temperatures, humidity, chemical atmospheres, rapid reversals and other operating conditions. Includes list of silicone resins for impregnation. Silicones Div, Union Carbide Corp, 40 E 42nd St, NY 17, NY.

(C-157) Standard Plastic Parts—Catalog, 8 pp. Molded plastic handles, knobs and controls available. Harry Davies Molding Co, 1428 N Wells St, Chicago, Ill.

(C-158) ABS Polymers—Brochure, 8 pp. Lists chemical, electrical and thermal properties of acrylonitrile butadiene styrene resins. Product applications include molded parts, extrusions and formable sheet. Marbon Chemical Div of Borg-Warner Corp, Washington, West Va.

(C-159) Synthetic Sapphire—Bulletin, 4 pp. Describes wear resistant, insulating, infrared and light transmission properties of synthetic sapphire. Charts of thermal, electrical and optical characteristics, fabrication methods and suggested applications. Industrial Sapphire Co, PO Box 422, Quakertown, Pa.

(C-160) Custom Plastic Extrusions—Brochure, 8 pp. Describes physical properties, capacities, approximate dimenisons, available styles and typical uses. Color coding directions and samples of multi-cell tubes are provided along with data on materials. Jessall Plastics, Inc, Kensington, Conn.

(C-161) Polyethylene Products—Bulletin, 16 pp. Describes injection molding of polyethylene detailing typical applications, types, properties, molding techniques and technical services. Koppers Co, Inc, Plastics Div, Koppers Building, Pittsburgh 19, Pa.

(C-162) Lubricants—Bulletin, 28 pp. Guide to the selection and use of oils, greases and synthetic lubricants for miniature bearings in precision instruments. Miniature Precision Bearings, Inc, Precision Park, Keene, NH.

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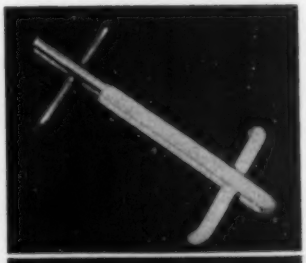

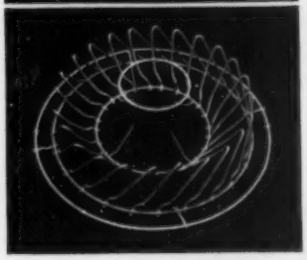

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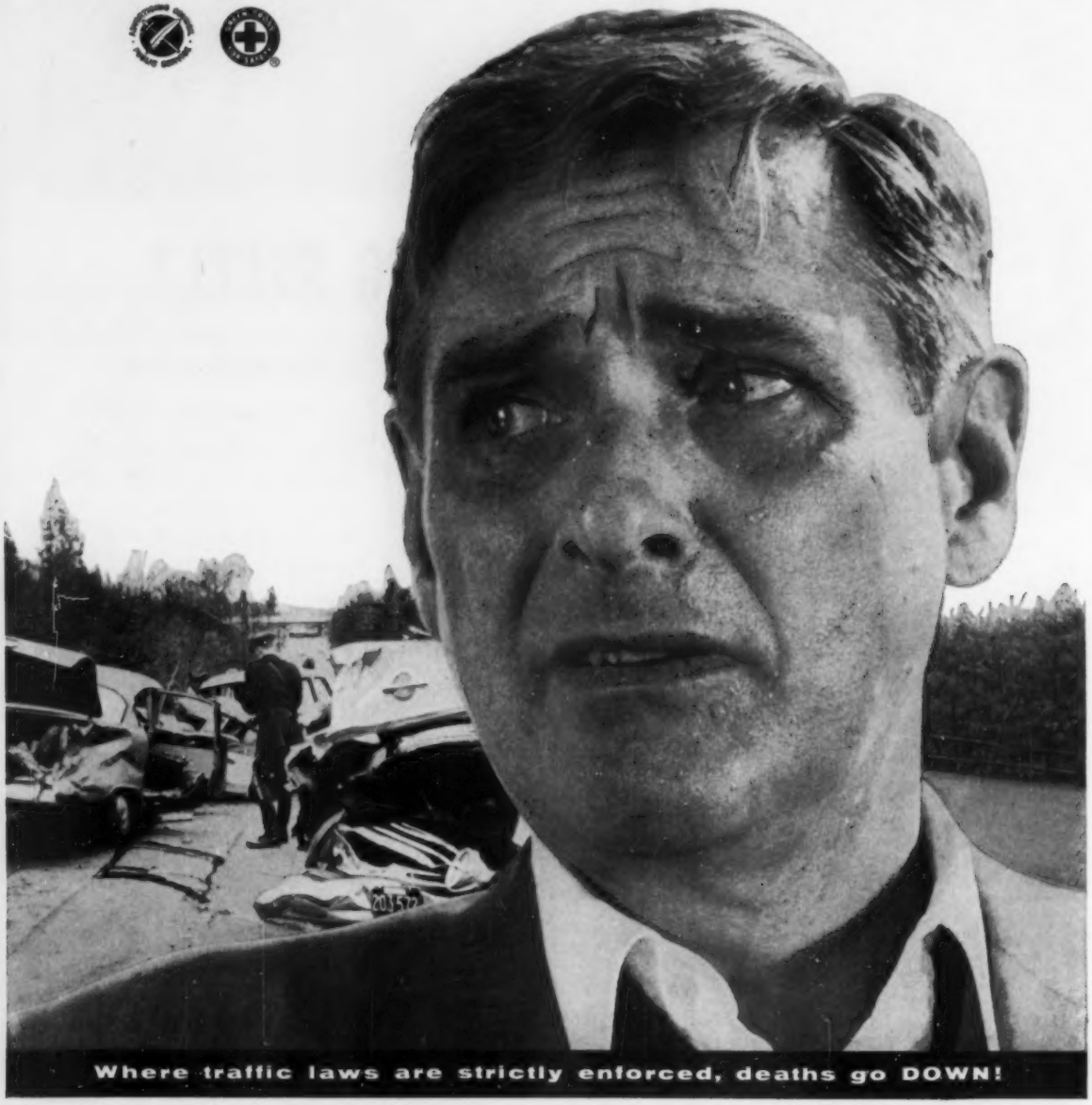

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SECTION D

FABRICATION AND PRODUCTION PROCESSES

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DESIGN ABSTRACTS

EXPLOSIVE FORMING

Shaping metal by explosives is not basically new. Explosive forming for production, however, is relatively recent. The list of present and possible applications is growing daily.

High Velocity

The success of explosive forming in accomplishing metal shaping is attributed to the high velocities at which metal movement takes place. These velocities are usually over 200 fps and sometimes as high as 15,000 fps. At these high rates of loading the pattern of metal behavior is drastically different from that observed during near static loading such as obtained when using drop hammers, brakes or hydropresses.

Each metal or alloy seems to have its own critical forming velocity. If the rate of metal flow is to high, the material may shatter. A reduction in the order of 50 to 100 fps from the critical velocity may result in good plastic flow characteristics.

"Superalloys Formed With Explosives," Paul J Wolf, Wright-Patterson AFB; The Tool Engineer, Dec '58, 239 E Chicago St, Milwaukee, Wis.

*

Machining Beryllium

Beryllium is a metal possessing a remarkable combination of properties. It exhibits an elastic modulus 40% higher than steel, a strength-weight ratio 30% greater than titanium, a density comparable to magnesium, roughly 40% of the electrical and thermal conductivities of copper, and the relatively high melting point of 2345 F. These properties could easily establish beryllium as a true "wonder metal" were is not for its brittleness, toxicity, and high cost. Beryllium, currently most used in x-ray windows, neutron sources, and moderators, and as an alloying element in copper, may become an important structural material for aircraft and related uses if cost and lack-of-ductility problems can be solved.

Beryllium is readily machined, but special precautions and procedures must be observed to avoid health hazards due to the toxicity of the metal and its compounds.

Conclusions

Beryllium chip formation is predominently a brittle-fracture process irrespective of the cutting speed, feed, or tool geometry used; however, some plastic flow of the chip is observed. Chip uniformity and surface finish improve with light feeds and high tool rake angles. Surface cracking, stick-slip friction, and built-up-edge formation on cutting tools are phenomena associated with beryllium cutting.

"Beryllium Machining Characteristics," Donald R Walker, Avco Manufacturing Corp; ASME paper 58-SA-43, ASME 29 W 39th St, New York 18.

*

Aluminum Bending

Versatile new hydraulic machines have been developed to increase production rates and extend the scope of operations in the bending of tubing, shapes, bars and rods. Problems such as springback are easily solved, and even anodized or precoated materials may be bent without marring the finish.

"High Speed Bending of Aluminum Tubes and Shapes," W A Osterland, Pines Engineering Co, Inc; Modern Metals, Jan '59, 435 Michigan Ave, Chicago 11.

*

Russian Welding

Since the first Sputnik was placed into orbit in October 1957, we have learned of the Soviet advances in rocketry, atomic energy, and basic science. What about progress in metalworking and fabrication technology—has it kept pace with advances in the more spectacular, attention-getting fields?

Current developments

A member of the United States group attending the conference on Vacuum Techniques in Steel at the Academy of Science's Institute of Metals in Moscow last summer had the opportunity to hear reports on current developments and to talk with a number of Soviet metallurgists and technologists in the metalworking field. This article discusses Russian practices in welding, progress being made in forging and extrusion and the use of special metal forming techniques.

"Welding and Metal Forming in Russia," Arthur B Tesmen, Baldwin-Lima-Hamilton Corp; Metal Progress, Jan '59, 7301 Euclid Ave, Cleveland 3.

*

Fabricating Beryllium Copper

Within the field of employment determined by its special properties, beryllium is most widely used in the form of beryllium copper. The combination in this alloy of high tensile, elastic and fatigue strength, hardness, good electrical conductivity, and resistance to wear and corrosion has established its usefulness where such properties are demanded for a variety of components in precision equipment.

"How to Treat and Fabricate Beryllium Copper," Metalworking Production, July 25, '58, 95 Farringdon St, London, E.C.4, England.

*

Machining Ultra-strength Alloys

Many alloys are new to industry and meager machining information is available for use in setting up production machining operations. For the more familiar materials such as the martensitic low alloy steels, hot work die steels and martensitic stainless steels, there is a lack of data for machining these materials in the high hardness ranges. Hence, a trial and error method must be used in the production operations which involves considerable time and expense. The loss of time due to development of the production machining process can seriously disrupt planned schedules.

This paper presents results of machinability studies made to date on

representative high strength thermal resistant alloys, divided into four groups: Martensitic low alloy steels; hot work die steels; precipitation hardening stainless steels; austenitic stainless steels.

"The Machining of Ultra Strength Alloys," John Maranchik Jr, J V Gould, P R Arzt, Metcut Research Associates Inc, SAE paper 43R, SAE, 485 Lexington Ave, New York 17.

*

Salt Bath Treatment

Salt baths have been widely adopted for various heat treatment processes for ferrous metals in the last fifteen to twenty years. The greatly increased use of the process has resulted from important changes in the method of heating the bath and a series of improvements in the composition of the baths themselves. The article describes their advantages (and disadvantages) and goes on to consider salt bath operation and applications.

"Salt Bath Heat Treatment Equipment and Methods," A G Gardner, A.I.M.; Mechanical World, March '59, 31 King Street West, Manchester 3, England.

*

Metal Cutting

The most widely-held opinions on such factors as tool life, productivity, chip formation, cutting temperatures, cutting fluids, finish, experimental work are summarized.

"What Is Known Today About Metal Cutting," F W Boulger, Battelle Memorial Institute, ASTE paper 44, 10700 Puriton Ave, Detroit 38.

*

Drawing and Rolling Metals

Apparatus based on initial investigations by Bridgman and extended by authors consists of free-running rollers used to draw or form metals under hydrostatic pressures up to 10,000 kg/cm². Liquid was pressurized by laboratory compressor rated at 3.8 liter/hr. Installation was used for experiments in forming and drawing to various degrees of deformation and although authors note improved properties, detailed results are not given.

"Apparatus for Drawing of Metals and Rolling Them with Free-running Rollers in Liquid Under High Hydrostatic Pressure," B I Beresnev and others. Tsvetnye Metally, USSR, March 1959. Translation available from Henry Brutcher, P O Box 157, Altadena, Calif.

*

New Joining Processes

Some of the newer developments in the field of joining metals are presented, and the further growth and possibilities in some of the newer fields of welding are described. Tabulated are 37 methods of welding, including brazing, under these main headings: Pressure welding, fusion welding, and brazing.

"Prediction in New Metal Joining Processes," John J Chyle, A O Smith Co, SAE paper 52S, SAE, 485 Lexington Ave, New York 17.

*

Investment Casting

Suggestions for designing parts to be made by investment casting are given. Tolerances, radii, straightness, flatness, concentricity, roundness, angles, parallel sections, holes, size and weight, minimum section thickness, serrations, finish, threads, parting lines and gating, draft, fillets are discussed.

"Designing for Investment Casting," Tool Engineer, Apr '59, 239 E Chicago St, Milwaukee, Wis.

*

Corrosion Resistance of Stainless Steel

The lower-cost stainless chromium steels combine resistance to corrosion with high strength. Although less corrosion resistant than the austenitic stainless steels, they are adequate for many mildly corrosive media like alkalis and organic acids. But optimum corrosion resistance depends on heat treatment and composition. Several pointers are given on properties.

- Avoid carbide formation. Carbides tie up free chromium that imparts passivity.
- Raise solution temperature to dissolve complex chromium-iron-carbides. These dissolve more slowly than the ordinary iron-carbides.
- Do not overheat. While corrosion resistance is not lowered by overheating, this coarsens grains and lowers toughness.
- Avoid tempering range from 870 to 1125 F.
- Keep free chromium above 11%. Percent chromium minus ten times carbon content should be at least 11%. However, free chromium much above 14%, while it gives still more corrosion resistance, lowers maximum hardness and consequently strength.

Abstracted from "Influence of Heat Treatment on Corrosion Resistance of Stainless Chrome Steels," by Dr. Ing. R. Pospisil, Czechoslovak Heavy Industry, Vol 10, '57, 13, Prague 1, Czechoslovakia.

*

Tooling for Development

Examples from the radio-tube industry illustrate comparatively low-cost methods of producing small quantities of parts of normal production quality for use during development of new products. Simple, inexpensive tubing designed for easy modification is pictured and described.

Abstracted from "Simple Shop Practices for Short Runs," H. J. Ackerman, L. J. Caprarola, G. C. Walther, Radio Corp of America; American Machinist, Jan. 13 '58, 330 W 42nd St, New York 36.

*

Plastic Metal-Working Procedures

A "high range" of plastic metal-working procedures (primarily compressive in nature) beyond point of normal tensile failure is described. Distinguished by steeper or more rapid rate of work-hardening. Testing technique designed to obtain physical properties from this procedure is described, together with its application to a rocket motor body application.

"High-range Plasticity of Metals Beyond Normal Work-hardening," E. V. Crane, W. S. Wagner, E. W Bliss Co, ASME paper 58-A-132.

From: GM Engineering Journal*

Design and Fabrication of Extruded Rubber Products

Although extrusion process is basically simple, many factors contribute to the the overall feasibility of extruding a specific product. Extrudability charts serve as guides in planning extrusions.

G. WILLIAM BECK
Assistant Chief Engineer—Product Design
Inland Manufacturing Division
General Motors Corporation

Rubber products are found in many applications where abusive action, such as repeated impact, continuous flexing, vibration, abrasion, and exposure to heat, oil, and chemicals, might occur. Many of the rubber products used have complex cross sections, some of which can be fabricated best by extrusion.

The extrusion process is simple, but there are many factors which must be considered before deciding to extrude a specific rubber product. The major factors governing the successful extrusion of a product can be integrated into the term extrudability. The extrudability of a product is the degree of perfection to which it can be extruded.

FACTORS AFFECTING EXTRUDABILITY

The important factors determining the extrudability of a given product are: (1) variation in cross section thickness and complexity of shape; (2) length of uncured piece to be handled; and (3) physical properties and kind of compound to be used.

Cross section. A part having uniform thickness can be extruded in softer material than can a cross section that varies from thick to thin. If a section is irregular in shape, support of the section during cure might be necessary to get the desired shape.

Length. Thin cross sections cannot be handled in straight lengths over 60 in. and still be held to close tolerances. Uniform tolerances can be held over the entire length of the extrusion if the design of the cross section is such that the product can be coiled during the cure cycle.

Compound. In general, closer tolerances can be held and thinner cross sections fabricated when using hard compounds than when using soft compounds. Also, compounds with higher tensile strength require greater tolerances and thicker cross sections than low tensile compounds.

Crude natural rubber, GR-S, neoprene, Buna-N, butyl, and silicone materials all can be compounded to extrude a variety of satisfactory cross sections. Because of the basic physical characteristics of natural rubber and the various synthetic polymers, it is more practical to obtain tensile strengths above 2000 psi with natural rubber and neoprene than with the other synthetics. 700 to 1200 psi is about the maximum obtainable tensile strength with silicone.

RELATION OF FACTORS AFFECTING EXTRUDABILITY

It is difficult to generalize about the effect of the many factors upon the extrusion of rubber products. However, several of these factors have been related in chart form, Figs. 1 and 2, to serve as guides in planning extrusion products. They can be used in several ways.

If one of the factors collated by the charts is given for a specific extrusion, the charts reveal the limitations that factor places on the nature

* The Journal is available regularly only to engineering educators and technical libraries.

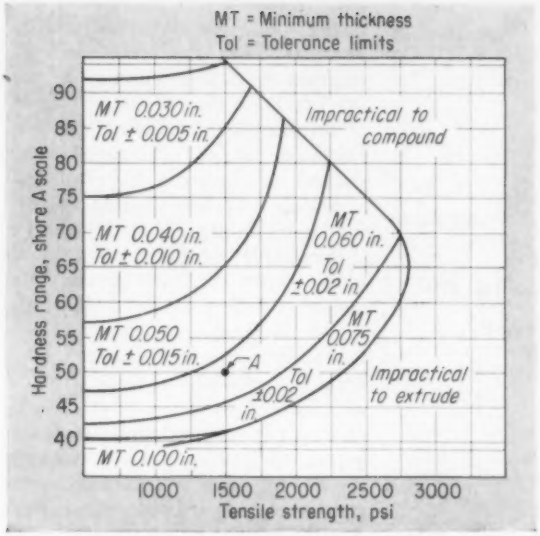


Fig. 1—Extrudability chart relates hardness, tensile strength, tolerances, and minimum thickness for rubber products of uniform thin cross section. Example: For a material of 50 Shore A hardness, 1500 psi tensile strength (point A), the product can be extruded with a minimum thickness of 0.060 in. and a thickness tolerance of plus or minus 0.020 in. If tensile strength and hardness specification fall outside the longest curve, the product is impractical to extrude.

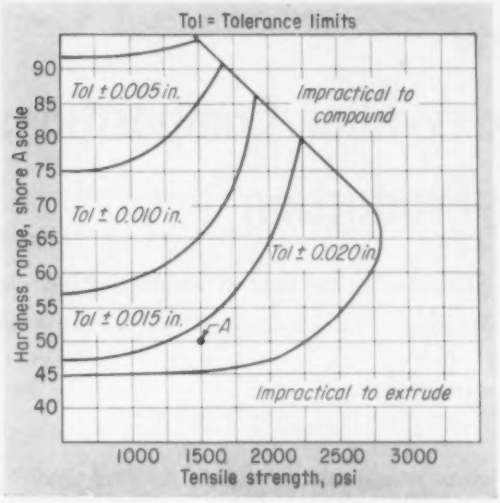


Fig. 2—Extrudability chart relates hardness, tensile strength and tolerances to rubber products of nonuniform cross section that vary from thick to thin. Example: For a material of 50 Shore A hardness, 1500 psi tensile strength (point A), can be extruded with a tolerance of plus or minus 0.020 in. If tensile strength and hardness specification fall outside the longest curve, the product is impractical to extrude and one of the variables—hardness, tensile strength, tolerance—must be changed.

of the extrusion. If more than one factor is given, the charts show how the relationship of the factors will affect the nature of the extrusion.

One extrudability chart relates hardness, tensile strength, and tolerance limits to the minimum practical uniform thickness that can be extruded satisfactorily, Fig. 1. If a rubber compound of a certain hardness and tensile strength should be used for a product, the minimum practical thickness that can be extruded and the minimum practical tolerances that apply can be determined. Similarly, if the uniform thickness is known, the chart will indicate the hardness and tensile strength values for a material suitable for extrusion.

The other chart, Fig. 2, relates the factors for extrusions of nonuniform cross section that have a great variation in section thickness. Two facts are apparent from Figs. 1 and 2; (1) hardness values must be higher for extrusions of nonuniform cross section; and (2) that closer tolerances are possible for higher hardness and relatively lower tensile materials.

The absolute minimum hardness for extrusions in nonuniform thin sections is 45 Shore A against 37 Shore A for uniform thickness extrusions. The minimum hardness of 45 would be covered by a specification of 50 plus or minus 5 Shore A, and is interpreted to mean that 50 is the minimum hardness that could be specified. This condition exists because of the higher swell characteristics of the softer materials and the difficulty met in attempting to build an extruding die that will produce thin sections adjacent to thick sections.

The closer tolerances indicated for higher hardness and relatively lower tensile materials are in line with the thinner extrusions permissible in these same physical ranges. Relationship exists because of the lower swell characteristics of materials in these hardness and tensile ranges.

The application of the second chart is similar to the first. If a set of requirements for the material is given, a partial extruding tolerance can be determined. If, on the other hand, the product application demands close tolerances, the chart can be used as a guide to determine a specification for hardness and tensile strength of the extruded material.

The extrudability charts are intended only as guides. It is probable that many production applications of extrusions violate the limits shown on the two charts. But, more than likely, a higher cost is reflected in these parts because of higher scrap allowance, higher handling costs, or higher material costs resulting from the use of specialized compounds.

REFERENCE:

Special Charts Aid the Design and Fabrication of Extruded Rubber Products by G. William Beck, Assistant Chief Engineer-Product Design, Inland Manufacturing Division, General Motors Corporation, Dayton, Ohio. Published in the General Motors Engineering Journal, Jan, Feb, March, 1959, p 18-20.

From: ASME Paper

New Epoxy-fiber Compositions for Production

Basic principles in the field of metal-fiberized plastic tooling and the wide range of possibilities of this technique are discussed.

A. P. MAZZUCCHELLI
Development Laboratories Union Carbide Plastics Company

New epoxy compositions have been developed which use metal-fiber reinforcement to extend the advantages presently given by plastic tooling to the field of metal fabricating. Metal fibers as a reinforcement for heat-resistant epoxy resin systems give reinforced castings with abrasion resistance, impact strengths, heat-distortion points, and thermal conductivities greatly in excess of conventionally filled, room-temperature compositions.

Improvement is so great that these compositions are used for the more difficult prototype jobs and many medium-run production jobs. In addition, metal fibers give a high degree of machinability, and a control of exotherm heat which permits epoxy castings with low shrinkage.

Three types of reinforced, heat-resistant epoxy compositions are under investigation: steel; aluminum; and combinations of steel and glass fibers. For best performance for tools and dies a special application technique is required: a face coat of short metal fibers is flocked or sprayed on the pattern or mold used for fabricating the reinforced casting. Glass or metal fibers are used for the body of the casting; but, for best results, it is necessary that this face coat of chopped metal-fiber flocking be applied to the surface of the casting. It is essential for satisfactory die performance, but also, the metal fibers flocked on the surface prevent the resin face coat from sagging on corners and vertical walls of die molds.

Specifically, the three compositions most suitable for metal-forming dies and other tooling use are: a mass casting of a heat-resistant epoxy resin system reinforced with low-carbon steel fibers of continuous or varying length and surfaced with a face coat based on an epoxy resin and steel-fiber flocking; a mass casting of a heat-resistant epoxy resin system reinforced with glass fiber and surfaced with a face coat based on an epoxy resin and steel-fiber flocking, the face coat sometimes backed with a steel fiber mat; a mass casting of a heat-resistant epoxy resin system reinforced with aluminum fibers and surfaced with a face coat based on an epoxy resin and aluminum-fiber flocking. Commercially, these compositions are designated Epoxy-Alloys ES, EG-SF and EA, respectively.

TABLE 1—RANGE OF PROPERTIES*

A Standard Heat Resistant Epoxy and New Fiber-Reinforced Epoxy Compositions

	Unfilled	Composition ES	Composition EG-SF	Composition EA
Type of Fiber	.....	Steel	Glass***	Aluminum
Specific Gravity (D792–50)	1.15	2.25	1.55	1.8
Flexural Properties (D790–49T)				
Ultimate Strength, psi	17,500	11,000–16,000	16,000–29,000	8,500–13,500
Tang. Prop. Limit, psi	11,000	6,500–8,300	12,000–25,000	5,300–7,500
Modulus of Elasticity, 10^{-6} psi	0.5	0.8–1.6	1.4–1.8	0.9–1.9
Compressive Properties (D695–54)				
Ultimate Strength, psi	33,500	12,500–28,500	21,000–29,000	12,000–21,000
Tang. Prop. Limit, psi	11,000	6,500–18,500	14,000–20,000	7,500–12,000
Modulus of Elasticity, 10^{-6} psi	0.4	0.4–0.8	1.2–1.8	0.6–0.9
Compressive Prop at 200 F. (D759-48)				
Ultimate Strength, psi	.....	7,700–22,500	16,000–22,000	8,900–14,000
Heat Distortion (D648), F	275F	400F	400F	400F
Rockwell Hardness (D785–51)	M114	M72–M82	M103–M111	M56–M81
Izod Impact (D256–54T), ft-lb per in	0.4	0.8–1.6	11	0.7–1.6
Thermal Expansion Coef. (D696–44), F	88×10^{-6}	43×10^{-6}	.....	55×10^{-6}
Thermal Conductivity** Btu/sq ft/sec/F/inch	2.0	19–30	5	51–131
Maximum Operating Temperature, F	.....	350	350	350
Water Absorption (D570–54T) 2 in. × ⅛ in. disc—24 hr	0.16	0.30	.40	.35

*Properties measured perpendicular to casting pressure
**Modified Ingen-Hausz method as described in "Practical Physics" Marsh, White, et al., (1955, McGraw-Hill)
***With steel-fiber face coat.

PROCESS, PROPERTIES AND VARIABLES

As shown in Table I, the new metal-fiber-reinforced compositions give many improvements over unfilled and powder-filled, cast, heat-resistant epoxy systems. With composition EG-SF, for example, flexural modulus of elasticity is improved from 0.5 to 1.4 x 10^6 psi and Izod impact strength from 0.4 to 11 ft-lb per in. of notch; while with ES, flexural modulus improves from 0.5 to 1.2 x 10^6 psi, and impact strength from 0.4 to 1.2 ft-lb per in. Compositions create a homogeneous tool or die so that the danger of bond-line rupture, prevalent in conventional die between the metal core and resin face coat, is eliminated. Improved properties such as these make possible the extension of plastic tooling to more rugged applications.

Homogeneity and metal-fiber reinforcement can also result in a casting with excellent machinability characteristics, Table II, and the unusual characteristics of being magnetic when steel fiber is used. The outstanding

TABLE II—COMPARATIVE MACHINABILITY* OF VARIOUS EPOXY COMPOSITIONS

Material	Number of Holes Drilled	Time in Seconds Required to Drill Last Hole
Composition EA	120	6
Composition ES	120	10
Unfilled Heat-Resistant Epoxy	120	6 (severe chipping)
Heat-Resistant Epoxy Iron Powder-Filled	103	300 (severe chipping)
Composition EG-SF	100	300

*By drilling 5/32 in. holes under constant load into ½ in. cast and noting drill wear.

Table III—Wear Comparison Between Composition ES and Standard Plastic Tooling Materials

As Measured in a Hydroform Ash Tray Die Test (177 stampings of various gages of metals)

Compositions	Draw Radius Change (Initial 0.156 in.)	Remarks
Low-rigidity polyester with steel fibers	Failures	Porosity Breakdowns Considerable creep
High-rigidity polyester with steel fibers	Failures	Breakdowns Fatigue failures
Medium-rigidity polyester with steel fibers	Failures	Porosity Breakdowns
Low-rigidity polyester with glass fibers	0.13	No breakdowns Considerable creep
Room-temp. epoxy-surfaced aluminum core	0.05	Initial radius 0.172 No breakdowns
Composition ES	0.02	No breakdowns

toughness of the materials permits easy retention and support of dowels, screws, and steel cutting edges. In addition to impacting necessary abrasion resistance to the surface of a metal-forming die, the metal fibers flocked on the surface facilitate retention of the face coat on the corners and vertical walls of the die mold during fabrication.

A wide number of variations, which may have an accompanying effect on properties, are possible in fabricating these materials into tools and dies. Broadly, the fabricating procedure consists of pressure casting a heat-resistant epoxy resin system with metal fibers, or with glass fibers and metal-fiber reinforcement.

As an example of the effect on properties that may be obtained by variations of the standard procedure, the impact strength of composition EG-SF rises to over 32 ft-lb per in. of notch when casting pressure is raised from 50 to 125 psi and glass fiber from 50 to 62%.

Physical properties are also affected by variation in fiber length, with these properties improving as the length of fiber is increased. However, as fiber length decreases, homogeneity and easier handling are gained. For mass casting, ¾ in. to 2 in. fibers have been found to be the desirable range for the best balance of properties. Very short metal fibers of ¼ in. length are used for flocking the face coat and do not appear to degrade properties seriously, maintaining triple the modulus and about double the impact strength of the unfilled resin.

One of the most important characteristics of these compositions is their mass castability without sacrifice of toughness and other physical properties. The presence of metal or glass fiber reinforcing avoids the excessive peak exotherms and concomitant high shrinkage and internal strains, normally encountered with metal-powder filled systems. Composition ES has a thermal conductivity ten times greater than an unfilled heat-resistant epoxy system. Composition EA has a thermal conductivity 60 times greater and 15 times greater than a system containing aluminum powder.

In the fabrication of tools and dies each composition has its own advantages and gives a range of choice to meet the needs of specific applications.

Composition EG-SF, for example, offers some fabricating advantages over ES and EA, with extrapolation to complex automotive dies easier at present. Casting pressure required for EG-SF is 50 to 100 psi as compared with 200 to 300 psi for compositions ES and EA. Mold box buildup height is ½ the depth of the cast for glass fibers, as compared with a buildup height of three to four times the depth for metal fibers.

Mobility under pressure and the mechanical properties of a premix are the factors that generally reduce cost of buildup, press size, and minimize pattern and plaster mold problems. Since a resin-glass fiber premix such as EG-SF, has mobility under pressure, it uniformly fills out greatly contoured dies. In contrast, available metal fibers show little or no lateral movement during casting, and greater care must be taken in loading to obtain uniform fiber distribution. Also, the mechanical properties of EG-SF are superior to those of ES and EA.

However, ES and EA compositions have some advantages. Greater care must be taken with EG-SF to apply the steel-flocked face coat uniformly and to avoid bridging of the glass fibers in sharp contours. The resin system and glass fibers for the mass must be premixed in separate operations; in ES and EA, the mass is directly pressure cast. Also, ES and EA have better machinability and give materials which are homogeneous, an important characteristic when making die changes or repairs. Thermal conductivity of ES and EA are better than EG-SF; both may be heated by induction or resistance. While the mechanical properties are below those of EG-SF, commercial performance has indicated that the ES and EA compositions are adequate for their particular tooling applications:

FIELD EVALUATIONS

In the absence of conventional end-use data for correlation with the physical properties of these new compositions, a series of field evaluations was made involving several types of tool and die operations. Hydroform dies, draw dies, and vacuum forming dies were evaluated using different materials and various shapes.

One series, used a 4 in. dia, 1 in. deep, ash tray die, and was evaluated in a rubber pad press using a 6 in. dia blank without lubricant. Stampings were formed over a 0.156 in. radius, using 0.025 in. and 0.060 in.

Table IV—Comparison Wear of Terminal-Box Test Draw Dies

Compositions	Number of Stampings .038 C.R.S.	Draw Radius Change over initial .109 in. Corners with 2⅜ in. depth draw	Straight edge with 1¾ in. depth draw	Change in Inches of Die Size Below Radius over 4 in. square	Remarks
Polyester-Glass Pressure Cast (PG)	200	Eroded	+0.06	Not measured	Severe erosion and breakdowns
Room-Temp. Epoxy Surface Coat on Iron Core (RTESC)	200	+0.12	+0.04	−0.006	Very severe galling and erosion
Heat-Resist. Epoxy-Glass Pressure Cast. Glass Flock Face (EG-GF)	500	+0.05	+0.03	−0.005	Uneven wear, ridging due abrasion
Heat-Resist. Epoxy-Glass Pressure Cast-Iron Powd. Face (EG-IPF)	1000	+0.03	+0.01	−0.005	Slight uneven wear and ridging. Face coat application difficult
Heat-Resistant-Epoxy Glass Pressure Cast Silicon Carbide Powder Faced (EG-SCF)	1000	+0.03	+0.03	−0.005	Same as EG-IPF
Heat-Resistant-Epoxy Glass-Steel Flock Face (EG-SF)	1000	+0.08	+0.01	−0.001	Uniform wear. Face coat application easy
Heat-Resistant Epoxy Steel Fiber-Steel Flock Face (ES)	1000	+0.08	+0.03	−0.004	Uniform wear. Face coat application easy
Zinc Base Alloy	1000	0	−0.01	−0.009	Uniform wear, least erosion but creep and build-up metal flank on radius
Heat-Resist Epoxy Steel Fiber-⅜ in. Precision Cast Iron Face (ES-CIF)	1000 1000	0 0	−0.01 0	−0.009 0	No change. Process experimental

C.R.S., 0.75 in. S.H. brass, and 0.032 in. and 0.048 in. stainless steel. Results are shown in Table III, and indicate the ES composition to be superior to the other compositions. This preliminary evaluation demonstrates the greater latitude given by the heat resistant epoxy system both in toughness and resistance to radius change and breakdowns.

The most comprehensive evaluation work used a terminal box draw die in which the new materials were compared against current plastic die compositions and processes as well as against iron and a zinc base alloy. A 7½ in. dia circular blank of 20 gage, SAE 1010 cold rolled steel was used to form a 4 in. sq. commercial terminal box with a 1¾ to 2⅜ in. draw and containing a step or ledge where the stamping was normally trimmed.

Pressure casting was considered difficult because of the vertical side walls and inside ledge. The deep draw for the size of stamping, combined with a speed of operation of 600 to 1000 per hour developed temperatures of over 140 F with the dies varying between 115 and 144 F as measured 0.050 in. from the draw radius of the corners.

A summary of pertinent information is shown in Table IV. It includes draw-radius wear and type of wear of the more important die compositions. The dies are listed in the table in general order from poorest to best.

In addition to information obtained from metal-fiber-reinforced compositions in test dies, data are available from more than 60 commercial dies constructed from the new materials. The most representative of the commercial dies are shown in Table V which gives their performance records.

ADVANTAGES OF NEW COMPOSITIONS

The overall cost of these fiber reinforced epoxy compositions will vary, depending on the volume and specific combination used, but it will be generally in the range of present epoxy tooling materials. At the present time, dies made from these compositions, using present casting techniques, will cost more than a simple casting of compounded epoxy. For this reason, these materials are only intended for use where their particular properties are needed and their known advantages extend application to areas where conventional plastic tooling materials are marginal or unsatisfactory. Nevertheless, as shown in Table VI, there are still considerable savings over the cost of equivalent all-metal dies.

Furthermore, because of savings in machining and spotting, such die-cost comparisons often do not reflect entirely the cost and time advantages which normally accrue through the use of plastic dies instead of metal dies. These savings are well known and are also generally applicable to these metal-fiber reinforced epoxy tooling compounds. For example, in a refrigerator panel case, the actual dollar saving with plastic dies was not much greater than if all-metal dies were used. However, production was able to begin 5 weeks earlier.

To date, the performance records of commercial dies fabricated from these compositions confirm the results obtained with test dies. To summarize, they both indicate the following preliminary practical utility range for ES and EG-SF compositions. It should be noted that these commercial tools were built early in this program, during which time tooling techniques for reinforced dies with a metal-fiber-flocked surface were being evolved and still improved.

Prototype or Development Draw Dies. For deep draws of heavy metals, and large compound-contour stampings of up to ¼ in. thick stainless.

Prototype panels of 3/16 in. stainless steel have been drawn over a 2 in. radius to a depth of 18 in. without radius breakdown. Using 0.050 in. C.R.S., draw radius will increase from ⅛ in. to ¼ in. for a 5½ in. depth of draw after 300 stampings and to ½ in. after an additional 700 stampings.

Low-Production Draw Dies. For runs of 1000 to 10,000 stampings, without metal rings or inserts. Gage of metal and design of stamping will have to be considered.

For example, 1000 stampings of 0.038 in. C.R.S. can be made with a depth of draw up to 2½ in., if draw radius increase from ⅛ in. to ¼ in. is acceptable. In drawing the same number of stampings from 0.029 in. C.R.S. over a ½ in. radius to a depth of 1 in., the radius will remain sharper than ⅛ inch. For stampings above this range one blank-holder surface should be of metal. Using 0.036 C.R.S. for a 1¼ in. deep panel, 5000 stampings are possible with a draw-radius increase from an initial ¾ in. to ⅞ in., while 10,000 ⅝-in.-deep draws can be made with a radius increase from ¾ in. to ⅞ inch.

Table V—Performance of Commercial Fiber-Reinforced Epoxy Compositions

Name of Part	Composition Cast	Approx. Part Size and Draw, inch	Type Part	Performance Record
Radiator-Top Tank	ES Punch Iron die and ring	4 x 23 x 3	0.025 in. brass	Completed run of 11,000 stampings. Flange (0.06 in.) at trim line requiring repair after 4000.
Radiator-Top Tank	ES Punch and Pad. Iron ring	4 x 23 x 3	0.025 in. brass	Still running after 130,000 stampings. Used steel trim flange and ring. No maintenance.
Refrigerator-Bottom Panel 1st and 2nd draw	ES Contoured Punch and Pad Steel rings	16 x 21 x 1⅛	0.036 in. C.R.S.	Still running after 65,000 panels. No maintenance. One 0.08 in. draw radius increased to 0.19 in. after 5000 panels, remaining unchanged as 0.44 in. after 15,000 panels.
Charcoal-Broiler Tray	ES Punch EG-SF Die and ring	21 x 27 x 1	0.029 in. C.R.S.	Ran 1000 panels. Draw radius increased from 0.031 in. to 0.11 in. Now running with metal plate draw radius insert.
Cover-Draw Die	ES Punch EG-SF Die and ring	21 x 22 x 5½	0.050 in. C.R.S.	Completed run of 1000 stampings. Draw radius increased from 0.125 in. to 0.25 in. after 300 and to 0.50 in after 700 additional stampings.
Aircraft Housing	Es Punch and upper ring. Ampco-bronze inserted polyester/glass lower ring	28 x 15 x 3½	0.040 in. alum.	Still running after 500 stampings. Indicated no need for bronze inserts if ES lower ring used. Aluminum was not scratched.
Aircraft Reinforcing Section	ES-SF Punch and Pad	4 x 10 x ½	0.045 in. stainless stee	Completed 200 parts. Draw radius 0.37 in. remained unchanged; 0.06 in. radius ends increased to 0.18 in. and required metal inserting.
Aircraft Part	ES Punch EG-SF Die Steel rings	25 x 16	0.065 in. stainless steel	Still running after 200 parts. No difficulty.
Stringer Z Section Radial Forming Die	ES on aluminum core	40 x 2½	0.032 in. stainless steel	Still running after 80 parts. No difficulty.
Crosley Refrigerator Bottom Plate	ES Punch, Die and ring. Metal beads	36 x 29 x 3	0.038 in. C.R.S.	Tryout approved. Crosley refrigerator line and production abandoned.
Plastic Sign Vacuum Forming Die	ES	22 x 24	cellulose acetobutyrate methyl methacrylate	Still running after 2000 parts. No difficulty.
Vending Machine Panel, Heated Matched Mold	EA	64 x 32	0.060 in. polyester glass fiber mat	Made 728 panels. Scum buildup required cleaning every 20–80 panels. Steel pinch trim inserts in male mold had to be reinforced. Surface gloss wore. Heat up rate satisfactory and cure speed at 200 F about same as with metal die.
Green-Sand Rocker Arm Foundry Pattern	EA on Al core cope and drag	.....	Attained desired improved thermal conductivity and fewer rejects, due to sand drag, then R.-T. Epoxy.	Still operating after 100,000 castings.

Medium-Production Draw Dies. For runs of 10,000 to 50,000 stampings, in which contoured punches and pads are used with metal inserts, draw rings, and blank holders. Compositions ES and EG-SF can be used for areas which are not subject to considerable wear, for inside panels where radii of ½ in. are acceptable, or where wear can be tolerated.

Medium-High Production Draw Dies. For runs of 50,000 to 150,000 or more stampings of the thinner and more easily formed metals, such as 0.025 in. brass.

Thus, 50,000 stampings or more of such metals can be produced if bead radii are 1/16 in. or more, if very highly stressed radii are ½ in. or more, and if metal inserts are used on sharper radii wearing parts. Such dies will hold a screw-fastened insert satisfactorily and with less mark-off than with standard epoxies.

Flanging, Trimming, Restrike, and Secondary Operation Dies. Highly desirable because of superior machinability and toughness, plus ability to retain and support dowels, screws, and steel cutting edges.

Hydroform and Rubber Pad Forming Dies. Mass castability, abrasion resistance, and lack of scratching of soft aluminum and stainless steel provide advantages over current materials.

Stretch Dies. For more difficult, sharper radii, and for hot stretch forming dies where materials are marginal.

Fixtures and Gages. For special applications requiring mass casts for needed rigidity, or where heat resistance and abrasion resistance make it more suitable than materials in current large-scale use.

Potential uses for composition EA, which take advantage of its capacity for mass castability, high heat resistance, and high thermal conductivity, include: precision metal casting molds, heated matched molds (for low-pressure use), foam and expandable plastic molds, vacuum forming molds, slush molding dies, and foundry patterns.

TABLE VI—TYPICAL COSTS OF FIBER-REINFORCED-EPOXY DIES VERSUS METAL DIES*

Name of Die	Iron	Fiber-Reinforced Epoxy
Test Terminal Box	$2,500–4,000 1,218–1,330 (Zinc base alloy)	$982 (ES)
Refrigerator Bot. Panel		
1st draw	4,100	3,825 (ES)
2nd draw	3,015	2,740 (ES)
Radiator Tank Top	3,000–5,500	2,225 (ES)
Charcoal Broiler Tray	3,175–5,350	2,380 (EG-SF)
Vending Machine Panel (Matched Mold)	9,000–12,000 (Aluminum) 15,000–25,000	5,950 (EA)
Foundry Pattern	3,000	1,000 (EA)

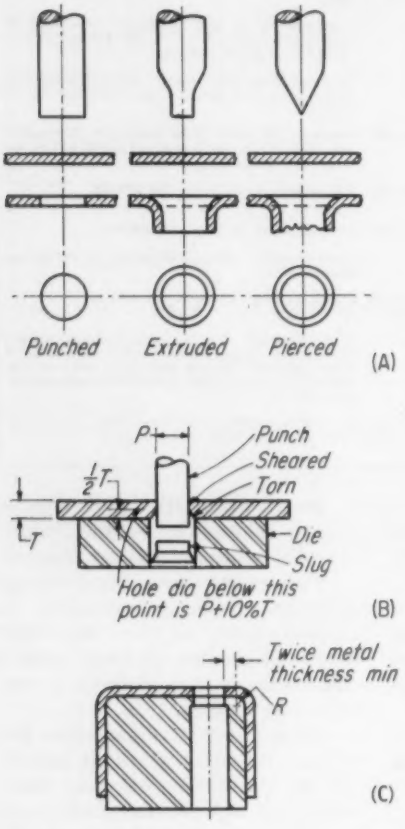
*As estimated by independent die shops.

REFERENCE:
For Tools and Dies—New Epoxy-Fiber Compositions, by A. P. Mazzucchelli, Assistant Director, Development Laboratories, Union Carbide Plastics Company, Division of Union Carbide Corporation, New York, N. Y. Presented at the 1958 ASME Annual Meeting, New York, Paper No. 58-A-244. Original presentation; 1958 ASTE Annual Meeting, Philadelphia, Pa.

From: Pressed Metal Institute

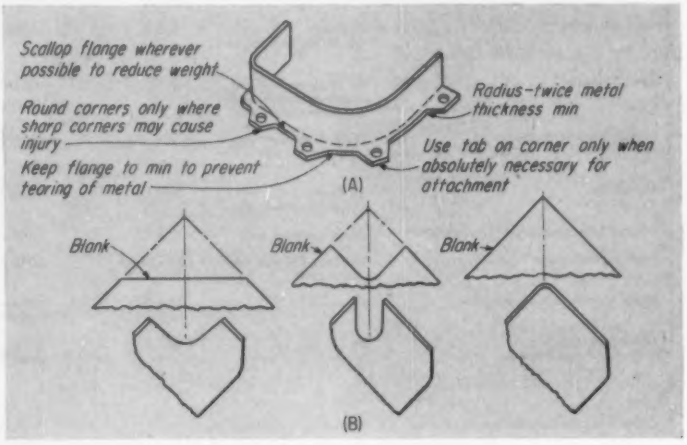
FACTS ABOUT STAMPINGS

Stampings offer economy, strength, appearance. Economy comes about through minimized waste of material, no final machining, and lower shipping costs of both raw material and finished part. Strength can be specified by the basic material and these range from copper, brass, aluminum and magnesium through the soft steels to include the hardest tungsten and carbide alloys. Appearance, again, is controlled by the basic material and its finish since it can be worked without fear of surface damage, marring, acids, abrasives or heat.



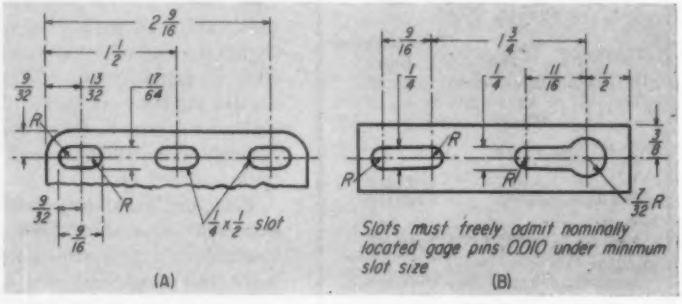
Holes . . .

. . . can be (A) punched, extruded or pierced. In designing stampings with punched holes only about ⅓ the thickness of the metal is sheared cleanly to the size of the punch. The rest is torn out by the pressure exerted on the sheared slug. This produces a rough hole tapering in diameter to the size of the punch hole about 10% of the metal thickness, (B). This is particularly important when the sides of the hole act as a bearing surface. The distance from the edge of a hole to the tangent point of a radius should be at least twice the metal thickness, (C). The distance between holes or the edge should be large enough to prevent tearing of the metal and excessive die wear.


Scallop flange wherever possible to reduce weight
Round corners only where sharp corners may cause injury
Keep flange to min to prevent tearing of metal
Radius-twice metal thickness min
Use tab on corner only when absolutely necessary for attachment
(A)
Blank
Blank
Blank
(B)

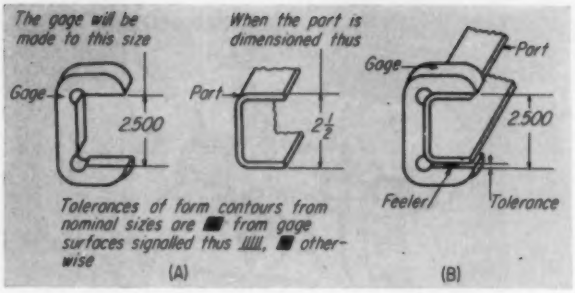
Flanges . . .

. . . whenever design permits make allowance for distortion and variation in tab shape and hole size to permit piercing and notching in the blank, (A). Tapered and outside flanges and flanges around opening should have a height of at least twice the metal thickness or a minimum of 0.12 in. on thin stampings. When designing box shaped parts, if the strength of the part is not involved, forming is less expensive than drawing, (B). Corners cut at 45° in blank permit folding flanges and often requires no further trim. Notching corner in blank has the same advantage as the 45° corners but often is more desirable for appearance. Continuous flange requires a draw operation.



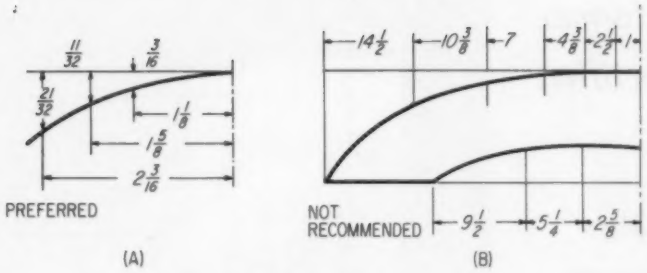
Slots . . .

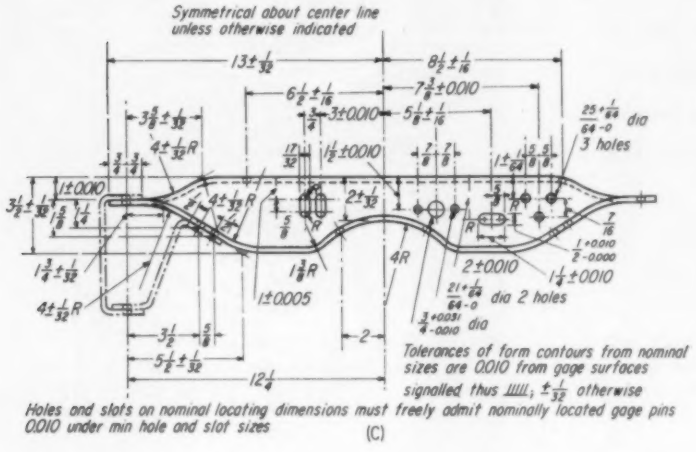
. . . of regular shape for the purpose of compensating for inaccuracies of manufacture or to provide for adjustment, (A), are dimensioned for size by overall length and width dimensions, and for location by dimensions to their centerlines. Slots which are intended to perform a mechanical function, (B), and where the size and location are subject to gage inspection are treated as two partial holes separated by space and dimensioned between radii.

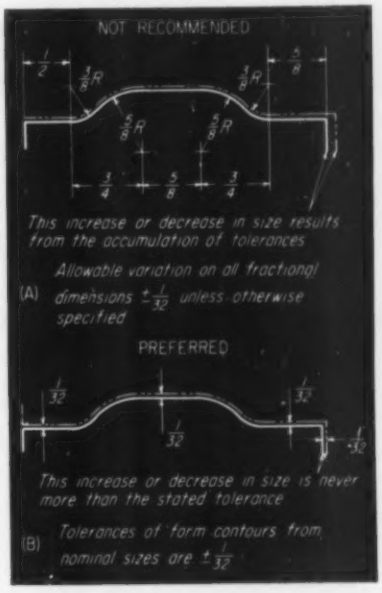


Gage inspection . . .

. . . is used on parts that have portions which match with mating parts, (A). Nominal dimensions should be specified for these mating portions with a statement that they conform to nominally sized gages within specified tolerances. A nominal dimension is used because it denotes the size of the gage, which is made to exact size. Tolerance indicates that the part is acceptable if it is produced in a size range which extends from maximum (completely filling gage opening) to minimum (loose in gage to specified value), (B). A feeler of the tolerance thickness is used to determine minimum size.




Symmetrical about center line unless otherwise indicated
3 holes
2 holes
Tolerances of form contours from nominal sizes are 0.010 from gage surfaces signalled thus //// ; otherwise
Holes and slots on nominal locating dimensions must freely admit nominally located gage pins 0.010 under min hole and slot sizes
(C)


NOT RECOMMENDED
This increase or decrease in size results from the accumulation of tolerances
Allowable variation on all fractional dimensions ± 1/32 unless otherwise specified
(A)
PREFERRED
This increase or decrease in size is never more than the stated tolerance
Tolerances of form contours from nominal sizes are ± 1/32
(B)

Dimensions . . .

. . . on stampings should be entirely to one side of the metal, either the punch side or the die side. Part of the dimensions should not be placed on one side and part on the other, except to provide for interchangeability of the matching portions of mating parts. Wherever possible, dimensions should be given to intersection or tangent points rather than to locus of a radius. Where a number of ordinates and abscissa are used, (A), to dimension a curved outline or series of holes, it is desirable to extend each dimension line to the base line, rather than to use other methods, (B), which may result in confusion. Groups that are not functionally related should show disassociation by being located from the prime base with dimensions carrying the maximum tolerances, consistent with good design. (C) is an example incorporating such dimensioning.

Tolerances . . .

. . . on a form contour or shape, (A), may accumulate and be objectionable. Where this occurs, a note, (B), should be used to express the tolerance. On drilled holes the tolerance should be as wide as possible. Hole size should be expressed in limits or tolerance, wherever possible, and avoid specifying the drill number or letter. Tolerances for punch holes should be as wide as possible, except for solid rivets where a plus 0.015, minus 0.000 is required and on draw rivets where the tolerance is plus or minus 0.005. Reamed holes should have a maximum tolerance of 0.0005 wherever possible. The minimum size should be determined by considering the fit desired and proportioning the tolerance between the hole and mating part so that maximum economy will result.

REFERENCE:

Facts About Stampings. Published by the Pressed Metal Institute (National Association of Metal Stampers), Cleveland 20, Ohio.

From: American Machinist

ARC-WELDING POWER SOURCES . . .

. . . dc motor generator
. . . ac transformer
. . . dc transformer-rectifier.

Until recent years, generators were the only power supply for arc welding, and all of the practices and equipment were originally based on the dc on which they supply. Today, equipment choice is based on the best welding process for the job and the significant operating characteristics of the various unit.

ARTHUR JOHNSON, Manager, Welding Equipment
KARL F. DUDEY, Electrical Design Engineer
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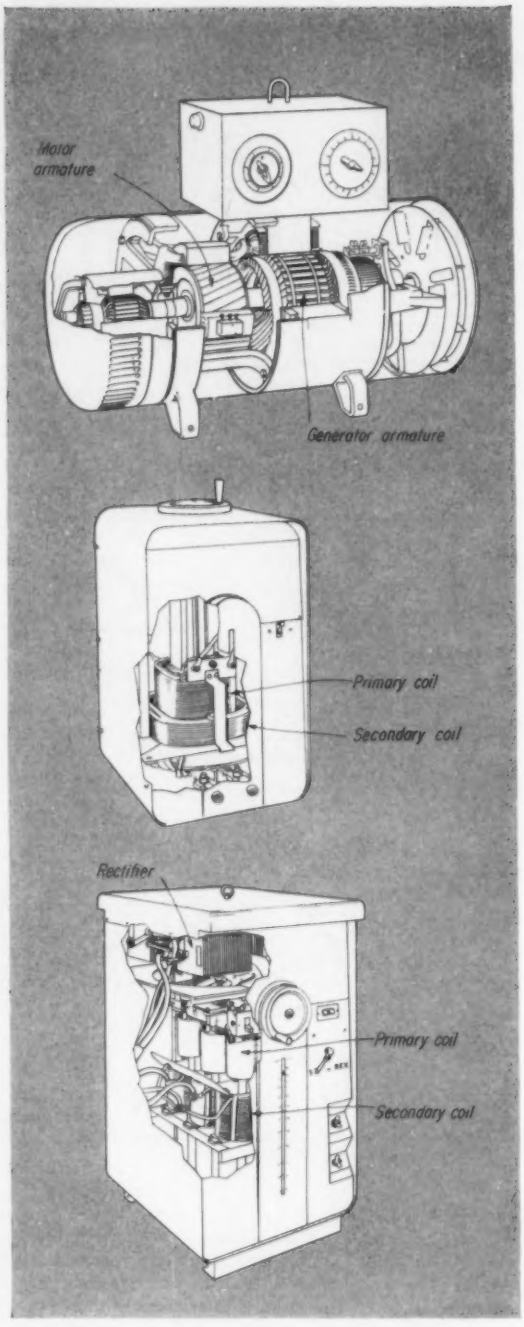


Arc-welding power sources are manufactured in all types and sizes to suit the requirements of different welding jobs and processes. However, there are only three basic types, two of them supplying direct current and the other supplying alternating current.

The ac unit converts single-phase power into the relatively low-voltage, high-amperage electricity required for arc welding. Basically, the transformer consists of a primary coil and a secondary coil, so there are no moving parts aside from the cooling fan. (Top two figures at right).

In the dc transformer-rectifier unit, a three-phase transformer adjusts the line voltage to the proper level, and then the rectifier plates convert the alternating current into direct current. Again, the only moving part is the cooling fan. (Bottom figure at right).

Power source selection is made on the basis of: (1) the type of welding process best suited for the job; and (2) the electrical characteristics of the power source.

MANUAL ARC WELDING

Ninety per cent of all manual arc-welding operations can be effectively performed with simple, single operator ac arc welding transformers and electrodes stabilized for ac power. These units cost about 40% less than the more complex dc machines of similar power rating.

WHICH WELDING APPLICATION FOR THE JOB . . .

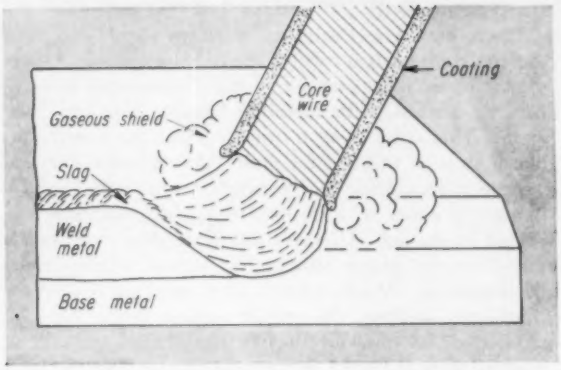


Fig. 1—Manual arc welding can be either ac or dc for most jobs. Dc has a more stable arc and can handle all jobs, but ac equipment is less costly and easier to operate.

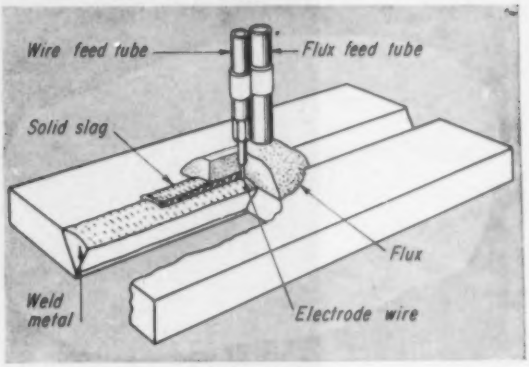


Fig. 2—Submerged arc welding is automatic or semi-automatic process, and can be powered by either ac or dc. It is used for heavy welding and high disposition rates.

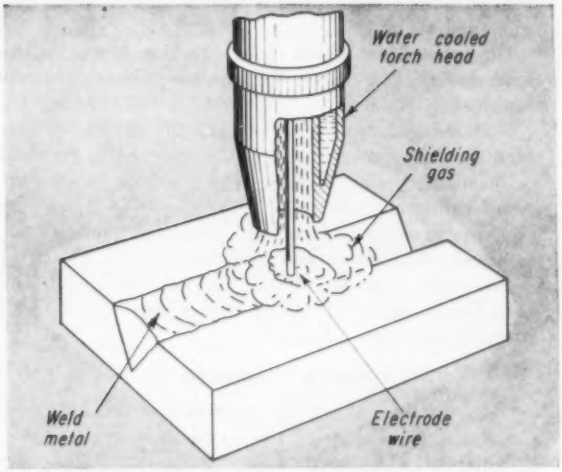


Fig. 3—Gas shielded consumable-electrode process is always dc powered. It is used to weld light-gage materials at high speed; can be automatic or semi-automatic.

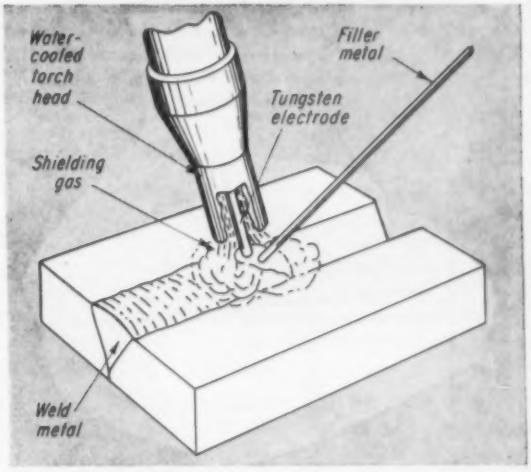


Fig. 4—Tungsten-electrode, gas shield arc is dc powered except for special jobs. It can handle difficult metals and may or may not use filler metal.

However, there is still 10% of manual arc-welding operations that cannot be performed with alternating current. If the work load consists wholly, or even partly, of these jobs, a dc power source would be more desirable.

Ac manual arc welding. These machines are generally available from 130 amp, 20% duty-cycle models capable of short time operation on electrodes of $\frac{3}{16}$ in. dia or less to 650 amp, high-duty cycle industrial units for operation with the largest available manual electrodes.

Dc manual arc welding. For complete flexibility and a power source that will handle all manual welding operations, direct current is the best choice. One advantage is that it produces a more stable arc than an ac unit which permits light-gage materials to be welded better. It is also preferred for heavy shipyard and construction work where welding is done in other than a horizontal position.

Dc single operator machines are available from 200 amps, limited-service units for intermittent use on electrodes up to $\frac{1}{8}$ in. dia through 600 amps, industrially rated units designed for the most continuous high-current manual welding operations.

AUTOMATIC ARC WELDING

Where large amounts of metal are to be deposited in either semi-continuous welds or high volume repetitive operations, the submerged arc and gas-shielded arc can be used to their best advantage.

Ac and dc submerged arc. Welding arc is submerged in a sea of molten and granulated flux applied external to the

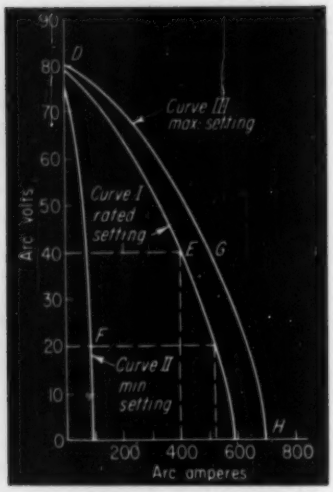


Fig. 5—Volt-ampere characteristic droop in ac or dc constant current power sources. Droop gives a small current change for a given change in arc voltage. Here, a 100% increase in voltage, from 20 to 40, results in only a 23% reduction in current, from 520 to 400.

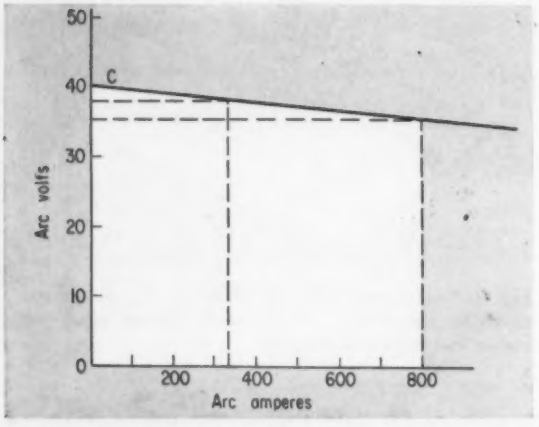


Fig. 6—Flat volt-ampere characteristic is typical of constant potential dc power sources. Here, an 8% change in voltage, 38 to 35, results in a 240% change in current, from 330 to 800 amps.

welding operation itself. The flux shields the arc and molten metal from oxidation, covers the hot weld, and eliminates arc spatter.

Usually the process is used for heavier than 14-gage metals and especially for filling deep seams. The power source may be ac or dc with either constant current or potential characteristics.

The ac transformers and control circuits are best suited to heavy plate work and welding where continuous seams are required on the assembly.

Dc is more frequently applied to light-gage metal and welds of a less continuous nature where more stops and starts are involved.

Power output and duty cycle ratings should be given special consideration when picking automatic power sources. Special high-output ac transformers and dc rectifiers are available with capacities between 800 and 2000 amps. This equipment is usually rated for continuous operation as is required for most automatic operations.

Automatic welding can be supplied with power from a number of either ac or dc manual welding machines connected in parallel. However, the 60% duty cycle rating found on the power sources for manual welding must be considered. When a 60% rated machine is used for continuous welding, the output current rating must be reduced by 25%. Thus, a 500 amp manual arc-welding machine is rated at 375 amp for continuous service.

Gas-shielded arc. An alternate process for depositing weld metal makes use of an inert or semi-inert gas flooded over the immediate arc area to shield the molten metal from oxidation. Most popular shielding gases are helium, argon and CO_2.

The exposed arc allows visual checking of weld alignment and quality. Also; there is no powered flux and slag cleanup problems.

Units using consumable electrodes are capable of handling the deep-groove welding and casting repair common to the submerged arc process, as well as high speed welding of light-gage materials.

Nonconsumable electrodes are useful for stainless steel, aluminum, magnesium and nonferrous alloys. Materials of very light gage are welded without filler metal, and when filler is required for the thicker materials, it is added externally as in gas welding.

ELECTRICAL CHARACTERISTICS

Once the type of welding operation is decided upon, a careful study of electrical characteristics should be made. Volt-ampere characteristics, open-circuit voltage, duty cycle, efficiency and power factor should all be considered when comparing power sources. Output characteristics. Most important of these considerations is the **volt-ampere relationship.** In general, all manual arc welding and tungsten arc welding must be performed with constant-current power sources. Automatic and semi-automatic processes may be powered by either constant-current or constant-potential machines.

With constant-current, a change in voltage will cause only a small change in current. Thus, the burnoff rate is relatively stable, and the arc is easily controlled.

Shown in graphic form in Fig. 5, curves I, II, and III represent the volt-ampere characteristics for rated, minimum and maximum current settings of constant-current power sources. *D* is the max open circuit voltage.

Point *E* is at the intersection of the rated load voltage and the rated load current. The rated volt-ampere characteristic pass through this point. The minimum load current at 20 load volts must be less than 20% of rated load current, shown as point *F*. The minimum volt-ampere characteristic must pass through this point.

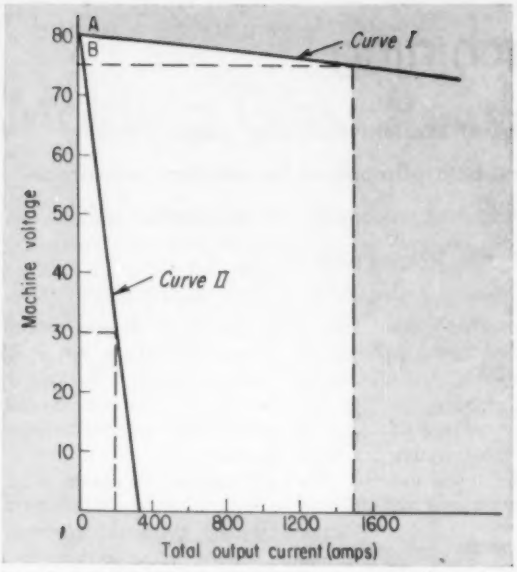


Fig. 7—Multi-operator power source is essentially a large scale dc constant-potential unit. It can be cut down by resistance grids to supply suitable power to a number of operators for manual arc welding.

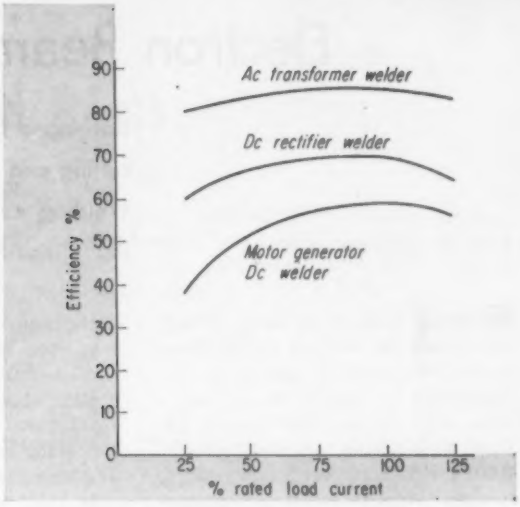


Fig. 8—Efficiency of the three types of welders. Ac transformer has best efficiency but it cannot be used for all types of work. Dc rectifier unit is more expensive to operate but it can be used regardless of type of job. Ac transformers and dc rectifier units operate at higher efficiency on light loads and have negligible no-load power losses.

Maximum load current at rated load voltage must be at least 25% above rated load current, point G. The maximum volt-ampere characteristic must pass through this point on the curve.

Constant-potential makes use of a relatively flat volt-ampere curve. A small change in arc length and arc voltage will cause a large change in current and burnoff rate.

The maximum volt-ampere characteristics are shown in Fig. 6. Tap switches and vernier controls are provided so the voltage can be reduced to almost zero, but the original slope of the curve does not change. Point *C* is the maximum open-circuit voltage which can be supplied by the machine.

The difference between these concepts is the methods used to control the arc. With constant current, the burnoff rate is established by setting the amperage. Any variations in arc voltage are sensed by a feedback device that adjusts the speed of the wire feed motors to restore the proper arc length.

With constant potential, the filler wire is fed by a simple, adjustable-speed motor. The arc voltage, instead of the amperage is pre-set, and the burnoff rate established by the wire feed motor.

Another power source is the multi-operator unit for large volume manual arc welding. Curve I, Fig. 7, shows the output characteristics of a typical unit rated at 75 volts. Point A is the open-circuit voltage, and point *B* is the voltage at rated output. Voltage drop is small as the machine is loaded, hence short-circuits cannot be tolerated.

Condition is controlled by adding external resistors or reactors. This changes the output characteristic to Curve II. The slope of the curve varies with the amount of resistance or reactance added and can be made suitable for manual arc welding when each operator is provided with a separate current limiting device.

Duty cycle. This is a percentage of a 10 min period that a welder can operate at its rated current without exceeding proper operating temperatures. If operated above the rated current, the duty-cycle must be reduced; or if, the rated duty cycle is exceeded, the current output must be reduced to avoid overheating.

Efficiency. Dc motor generator units have the lowest efficiency of the three types because its large mass must rotate at high speed regardless of powder delivered. Ac transformers and dc rectifier units operate at higher efficiency on light loads and have negligible no-load power losses. Fig. 8 indicates the efficiency values for the three types of power sources.

Power factor. Welding characteristics are not affected by power factor. Its only effect is on the cost of incoming power. Poor power factor is inherent in constant-current units and power-factor-correcting capacitors can be added to reduce operating costs.

Plants having large synchronous motors operating air compressors and other equipment may not require correcting capacitors. Synchronous motors have a favorable influence on power factor and may be able to keep the overall power factor within acceptable limits.

REFERENCE:

How to Choose Arc-Welding Power Sources by Arthur Johnson, Manager, Welding Equipment, Engineering & Development, A. O. Smith Corp, Elkhorn, Wis, and Karl F. Dudey, Electrical Design Engineer. Published in American Machinist, August 11, 1958, Special Report No. 463, p 97-104.

Electron Beam Machining

Developed by Carl Zeiss of Western Germany, electron beam cutting and welding are both offshoots of the electron microscope. Welding, coating, melting and machining are all possible with slight modifications to the basic machine.

From: American Machinist

Electron beam equipment, already being used for welding and melting, is now being used for machining. The equipment is capable of cutting a clean edge slot or hole through the toughest materials to a slot width of 0.0015 in. or less. With tape control, it cuts extremely accurate, intricate profiles. And there is no cutting tool, therefore no tool wear.

In both the welding and cutting machines, electrons are emitted from a heated tungsten filament into a beam-forming cup at the top of the machine. This cathode system operates on a negative dc voltage with respect to the ground, regulated steplessly from 25 to 125 kilovolts. The bias potential on the cup is adjusted from 0 to 1000 volts..

Slightly below the cup is a grounded anode ring. The electrons pass through this ring and into the workpiece at velocities ranging up to 102,000 miles per second. The electrons are aligned by two sets of four electromagnetic coils. Below this, an electromagnetic lens focuses the beam into the workpiece.

In the focusing lens, is the major difference between the welding and cutting machines. The cutting machine has a stigmator control which focuses the beam into a smaller diameter than required for welding. Also, the energy concentration is raised so that it vaporizes the work material; in welding, the material is melted.

In experimental work, the equipment has drilled a hole only one micron in diameter—39 millionths of an inch—and normally the beam diameter is half the diameter of the hole it drills. On a production basis, the equipment is being used to pierce bearing jewels for instruments, drilling tiny patterns in spinnerettes, and other micro-miniature work such as injection nozzles. Even in the hard synthetic sapphires used in jewel bearings, the beam vaporizes holes as small as 0.001 in. in diameter.

But, while the beam is being focused into a small area, energy is also being focused and concentrated. Therefore, for the smaller holes and slots, lower power settings are used.

HIGH-TEMPERATURE EFFECTS

Operating temperatures up to about 11,000 F have been used. Presumably, higher levels are attainable with a greater power input. However, this temperature has been adequate for any welding, drilling, or cutting the equipment has been called upon to perform.

High temperatures naturally bring up the question of what happens to the metal adjacent to the cut. In any sort of heat cutting, some of the metal in this zone will be raised above the transition point and will cool in a crystallized cast structure.

Electron-beam cutting does not escape the problem entirely, but the width of the heat affected zone is held to about 10% of the width of the cut. The reason is in the pulsed beam that bombards the workpiece intermittently and therefore holds down the temperature rise in the surrounding metal. The pulse generator operates at any desired frequency from 1 to 30,000 cps, with pulse durations of 0.01 to 0.00005 seconds.

INSTANTANEOUS VAPORIZATION

When the beam is controlled by the pulser the work is subjected to short bursts of electrons that almost instantaneously vaporize the workpiece in the small area where they strike. Much of the heat is thus carried away by the vaporized metal.

The depth of cut with the present equipment has ranged up to ¼ in. Width of cut is much smaller because the beam has to be highly concentrated. However, width is not a significant factor; if a slot 2 in. long by ⅜ in. wide is desired, the outline could be traced and the material dropped out of the middle.

For most cutting the beam is adjusted to make a straight-sided cut as it passes through the work. However, a unique feature of the equipment is that the beam can be intentionally focused to converge sharply to a point at the bottom of the workpiece. In drilling a hole, this arrangement would produce a cone-shaped hole with the apex at the bottom. Using the same principle, the work can be transversed, and the beam will cut a V-shaped slot with the apex at the top or the bottom of the piece as desired, and to any width of cut.

BLIND HOLES BY ELECTRON-BEAM

Normally, a cut is made clear through the work, but bottoming cuts or holes are also possible. Unlike the conventional gas cutting torch that does some of its work by melting the metal and then pushing it out of the way, the electron beam actually vaporizes the metal.

Therefore, with proper adjustment of all the variables—power input, pulsation rate, beam concentration, and traverse speed or length of dwell—the depth of cut can be precisely controlled. Also, claimed for the equipment is three-dimensional machining. Magnetic tape will control the number of impulses directed at each minute section of the work to give the required shape.

REFERENCE:

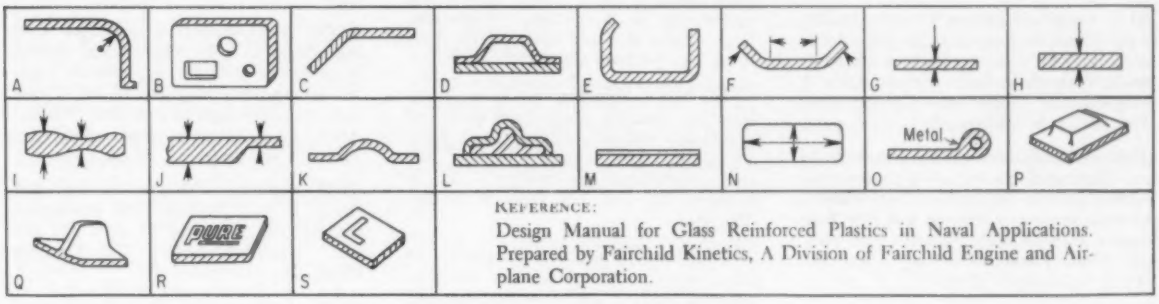
Electron-beam Machining by Richard T. Berg, Assistant Editor. Published in American Machinist, March 9, 1959, p 115-116.

Design Factors for

Molding Glass Reinforced Parts

An outstanding difference between glass reinforced parts and metal parts is its comparatively low modulus of elasticity or stiffness ratio. Because of this, stiffness must be designed into the part. Major advantage is that parts can be fabricated as single units rather than being assembled from many metal parts. This leads to economies in fastening, inspection, tooling, part design and handling, fab ication, molding and weight.

From: Design Manual



REFERENCE:
Design Manual for Glass Reinforced Plastics in Naval Applications. Prepared by Fairchild Kinetics, A Division of Fairchild Engine and Airplane Corporation.

Design Factors for Various Molding Processes

Design Factor	Example	Bag Molding	Flexible Plunger Molding	Vacuum Injection Molding	Matched Die Molding	Compression Molding
Min inside radius	A	2–3 times material thickness			1/8 in.	1/32 in.
Molded-in holes	B	Large only	No	No	Yes	Yes
Trimmed-in mold	C	No	No	No	Yes	Yes
Built-in cores	D	Yes	NR	Yes	NR	Yes
Undercuts	E	Yes	Only slight	NR	No	NR
Minimum draft, deg	F	5	1	3	1	1
Minimum thickness, in.	G	1/10	1/16	1/10	1/32	NK
Max practical thickness, in.	H	1	1/4	1/2	1/4	NK
Normal thickness variation, in.	I	±0.020	±0.015	±0.020	±0.008	±0.002
Max thickness buildup, in.	J	AD	2 to 1 max	AD	2 to 1 max	AD
Corrugated sections	K	Core	Yes 1 in. R	Yes	Yes	Yes
Metal inserts	L	Yes	NR	Yes	P	Yes
Surfacing mat	M	No	Yes	NR	Yes	No
Max part size, sq ft	N	AD	100	1000	175	15
Metal edge stiffening	O	NR	NR	NR	Yes	Yes
Bosses	P	P	P	P	P	Yes
Fins	Q	Yes	No	No	Short, yes	Yes
Molded-in labels	R	Yes	Yes	NR	Yes	No
Raised No. or letters	S	Yes	Yes	Yes	Yes	Yes

P—Possible
NR—Not recommended at present time
NK—Not known at present time
AD—As desired

D FABRICATION AND PRODUCTION PROCESSES

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(D-1) Duplicating Attachment—Bulletin, 6 pp. Describes automatic tracing unit for milling application. Illustrates features and versatility of operation. Applications are shown. True-Trace Sales Corp, 9830 E Rush St, El Monte, Calif.

(D-2) Tanks and Process Vessels—Catalog, 4 pp. Describes pictorially the many forms of tanks and process vessels available in steels, clads and alloys. Graver Tank & Mfg Co, Div Union Tank Car Co, 4809 Tod Ave, East Chicago, Ind.

(D-3) Plaster Mold Castings—Brochure, 14 pp. Illustrated description of plaster mold casting process. Examples of applications of brass, bronze, aluminum and berrylium copper castings made through this process. Ohio Precision Castings, Inc, 111 Webb St, Dayton 3, Ohio.

(D-4) Malleable Iron Castings—Brochure, 8 pp. Examples of how malleable iron castings effect products and costs plus digest of physical properties for standard and pearlitic grades. Malleable Founders Society, Union Commerce Bldg, Cleveland, Ohio.

(D-5) Aluminum Castings—Brochure, 30 pp. Pictures and specification data sheets on close tolerance aluminum castings weighing up to 2000 lbs. Morris Bean & Co, Hyde Rd, Yellow Springs, Ohio.

(D-6) Tracer Milling—Bulletin, 8 pp. Hydraulic tracer control applied to vertical mills. Describes various models and typical applications. George Gorton Machine Co, 1321 Racine St, Racine, Wis.

(D-7) Threaded Stampings—Brochure, 7 pp. Cites techniques of stamping and threading parts, engineering information, examples of services performed plus cost and ordering information. The Mohawk Mfg Co, 1270 Newfield St, Middletown, Conn.

(D-8) Bronze Wear Plates—Brochure, 4 pp. Gives sizes, pieces and ordering information. Also technical information regarding product. Lamina Dies & Tools, Inc., PO Box 31, Royal Oak, Mich.

(D-9) Investment Castings—Brochure, 11 pp. Describes investment casting process, tolerances, and the alloys that can be cast. Investment Casting Co, 60 Brown Ave, Springfield, NJ.

(D-10) High-vacuum Equipment—Bulletin, 12 pp. Describes construction and application advantages in the field of high-vacuum processing; gives engineering information and describes laboratory equipment and facilities available. Rodney Hunt Machine Co, 198 Vale St, Orange, Mass.

(D-11) Custom Metal Fabrication—Catalog, 17 pp. Custom fabrication of consoles, cabinets, racks, chassis, panels, and weldments in aluminum, magnesium, steel, stainles steel and other metals. Falstrom Co, Falstrom Court, Passaic, NJ.

(D-12) Metal Spinning—Brochure, 5 pp. Describes spinning process and gives cost comparison between spinning and pressing; tables, charts, typical tolerances, and other engineering information. C W Torngren Co, Inc, 236 Pearl St, Somerville, Mass.

(D-13) Metals Processing—Brochure, 24 pp. Description of sintering and hot press processes used in producing tungsten carbide metal. Metal Carbides Corp, 6001 Southern Blvd, Youngstown, Ohio.

(D-14) Stampings—Brochure, 4 pp. Describes facilities, production capabilities and price data together with photographs of typical parts. WLS Stamping Co, 3292 E 80 St, Cleveland, Ohio.

(D-15) Screw Machine Products—Brochure, 4 pp. Contains photographs of sample products and listing of available equipment. The Locke Machine Co, Center St, Andover, Ohio.

(D-16) Aluminum and Zinc Die Castings—Brochure, 10 pp. Information on die casting design, process and applications. The Hoover Co, Die Casting Div, 101 E Maple St, North Canton, Ohio.

(D-17) Conveyors—Catalog, 12 pp. Illustrations, performance charts, applications and selection data for vibrating conveyors. Ajax Flexible Coupling Co, Inc, 72 Portage Rd, Westfield, NY.

(D-18) Tumbling Barrel—Brochure, 4 pp. Advantages and specifications of 30 x 48 barrel finish equipment. B W Elliott Mfg Co, Inc, 216 Prospect Ave, Binghamton, NY.

(D-19) Rotary Chipping Machine—Bulletin, 2 pp. Describes general purpose cleaning machine for removing paint, cement or rust from steel forms. Includes parts list. B W Elliot Mfg Co, Inc, 216 Prospect Ave, Binghamton, NY.

(D-20) External Bin Vibrators—Bulletin, 2 pp. Gives specifications and sizes in addition to features. B W Elliot Mfg Co, Inc, 216 Prospect Ave, Binghamton, NY.

(D-21) Numerically Controlled Positioning Table—Brochure, 6 pp. Describes positioning table mounted on single spindle drill press. Gives specifications, method of operation and punched tape preparation. Jones & Lamson Machine Co, 543 Clinton St, Springfield, Vt.

(D-22) Die Castings—Brochure, 14 pp. Mentions facilities available for production of die castings and lists various types. Twin City Die Castings Co, Talmage & 33rd Aves, SE, Minneapolis 14, Minn.

(D-23) Aluminum and Zinc Die Castings—Brochure, 20 pp. Description of manufacturing facilities, personnel, finishing and tool room equipment. Pressure Castings, Inc, 21500 St Clair Ave, Cleveland 19, Ohio.

(D-24) Heat-resistant Centrifugal Castings—Bulletin, 8 pp. Physical and thermal properties of materials, applications, facilities for manufacturing and testing of castings, and advantages of cast form. Electro-Alloys Div, American Brake Shoe Co, Taylor St and Abbe Rd, Elyria, Ohio.

(D-25) Precision Metal Services—Brochure, 8 pp. Facilities and equipment available for processing of strip, foil and wire. Hamilton Watch Co, Precision Metals Div, Lancaster, Pa.

(D-26) Tool and Die Steel—Brochure, 8 pp. Contains data on heat treatment, machinability and applications of low temperature—air hardening tool and die steel. Gives materials, fatigue properties and stock sizes. Universal-Cyclops Steel Corp, Bridgeville, Pa.

(D-27) Investment Castings—Catalog, 40 pp. Ferrous and nonferrous alloys. Describes process, design, alloy selection and applications. Precision Metalsmiths, Inc, 1081 E 200th St, Cleveland 17, Ohio.

(D-28) Centrifugal Castings—Bulletin, 12 pp. Explains special advantages of centrifugal castings as used in major metalworking industries. Lists chemical and physical properties of 80 steel, copper-base, and nickel-base alloys. Sandusky Foundry & Machine Co, W Market St, Sandusky, Ohio.

(D-29) Steel Weldments—Catalog, 4 pp. Describes various components, sub-assemblies, and others that can be fabricated and the facilities available. The R C Mahon Co, Box 4666, Detroit 34, Mich.

(D-30) Investment Castings—Brochure, 16 pp. Contains information on costs and performance of replacing machined or assembled parts with this process. The advantages and various steps in the casting manufacture are explained and illustrated. Hitchiner Mfg Co, Inc, Milford, NH.

(D-31) Forgings—Brochure, 24 pp. Facilities and equipment for the production of large impression die forgings. Also includes case histories of typical forging problems, plus marine, aircraft and automotive applications. The Park Drop Forge Co, 777 E 79th St, Cleveland 3, Ohio.

FABRICATION AND PRODUCTION PROCESSES D

(D-32) Castings—Brochure, 6 pp. Illustrates aluminum and magnesium castings for aircraft. Describes production and inspection facilities. American Brake Shoe Co, 530 Fifth Ave, NY 36, NY.

(D-33) Metalworking Machinery—Bulletin, 8 pp. Illustrations and brief description of machinery: expanders, shrinkers, roll formers, coilers, seamers, weld rollers and trimmers. Grotnes Machine Works, Inc, 5454 N Wolcott Ave, Chicago, Ill.

(D-34) Services in Fabricating, Assembling, Finishing—Brochure, 8 pp. Products and services of the company; contract manufacture of magnesium and other light metal assemblies. Brooks & Perkins, Inc, 1956 W Fort St, Detroit 16, Mich.

(D-35) Tube Mills—Catalog, 66 pp. Electrical resistance tube mills, description of tube mill processes, economics, engineering data and specifications for standard and auxiliary equipment. The Yoder Co, 5500 Walworth Ave, Cleveland 2, Ohio.

(D-36) Slitting Equipment—Brochure, 78 pp. Information on design, selection and operation of slitters; includes time studies, analysis of operating cycle, methods of coil handling, scrap disposal, specifications, capacity tables and data on accessories. Indexed for ready reference. Yoder Co, 5500 Walworth Ave, Cleveland 2, Ohio.

(D-37) Indirect Arc Furnace—Brochure, 4 pp. Designed for use in making precision castings up to 20 lbs with composite crucible provided with slag-free pours. British Machines & Foundry Supplies Ltd, 80 Shore Rd, Port Washington, NY.

(D-38) Diecasting Machines—Catalog, 16 pp. Describes a small high speed diecasting machine, and an automatic diecasting machine. Capacity of each is one pound in zinc. DCMT Sales Corp, 80 Shore Rd, Port Washington, NY.

(D-39) Hardened Steel Products—Catalog, 72 pp. Products, applications and manufacturing facilities for producing specially hardened steel products for heavy industry. The Tool Steel Gear & Pinion Co, 211 Township Ave, Cincinnati 16, Ohio.

(D-40) Cold Rollforming Equipment—Brochure, 90 pp. An illustrated analysis of the cold roll-forming process and equipment, includes discussion of end uses, advantages and commercial possibilities, and descriptions of basic and accessory equipment. The Yoder Co, 5500 Walworth Ave, Cleveland 2, Ohio.

(D-41) Contract Manufacturing Sheet Metal—Brochure, 6 pp. Facilities, list, and photographs of typical products. Extensive sheet metal fabrication facilities, deep drawings, stamping, bonderizing, degreasing and painting. Peter Gray Corp, 286 Third St, Cambridge 42, Mass.

(D-42) Pulsation Burner—Bulletin, 4 pp. Technical information regarding operation of burner, temperatures and capacities available, and application data. E W Bliss Co, 1375 Raff Rd, SW, Canton, Ohio.

(D-43) Cylinder-finish Tubing—Bulletin, 4 pp. Describes economies possible in fabrication of hydraulic equipment by use of cylinder-finish tubing, no boring or honing. Gives examples and data on tolerances, eccentricity, straightness and mechanical properties. Tube Reducing Corp, 520 Main Ave, Wallington, NJ.

(D-44) Special Products Tubing—Bulletin, 4 pp. Tubular parts in a variety of shapes and configurations. Examples and performance data given. Tube Reducing Corp, 520 Main Ave, Wallington, NJ.

(D-45) Special Steel Sections—Brochure, 4 pp. Describes various shapes and grades of steel available and applications of manufacturers using them. Gives examples of engineering information to determine feasibility of manufacture. Connors Steel Div, H K Porter Co, Inc, 5000 Powell Ave, Birmingham, Ala.

(D-46) Miniature Investment Castings—Brochure, 4 pp. Description and case histories of new techniques for producing miniature investment castings plus effect on volume and costs. Casting Engineers, Inc, 2323 N Bosworth Ave, Chicago 14, Ill.

(D-47) Investment Casting Process—Brochure, 44 pp. Covers design and engineering data on the investment casting process, the alloys cast, facilities, and various services. Arwood Precision Casting Corp, 321 W 44th St, New York 36, NY.

(D-48) Aluminum Alloy Castings—Catalog, 24 pp. Pertinent information concerning various aluminum casting methods, their applications, specifications and characteristics. The Permold Co, PO Box 70, Medina, Ohio.

(D-49) Wire Forms and Metal Stampings—Brochure, 6 pp. Describes typical wire forms and small metal stampings with emphasis on engineered parts for the electronic and glass-seal industries. The Art Wire & Stamping Co, 227 High St, Newark 2, NJ.

(D-50) Aluminum and Magnesium Forgings—Brochure, 36 pp. Shows in chart form the characteristics, uses, recommended heat treatment, typical mechanical and physical properties of forging alloys. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19, Pa.

(D-51) Tumbling Machines and Media—Brochure, 20 pp. Describes types of abrasive tumbling media, applications and selection of equipment. The Carborundum Co, Dept PE, PO Box 337, Niagara Falls, NY.

(D-52) Component Dispenser—Bulletin, 2 pp. Describes automatic machine which bends and cuts to length axial lead components for electronic assembly. Adaptable to job lot or line production. Schmit Engineering Co, 862 Fabian Way, Palo Alto, Calif.

(D-53) Screw Machine Products—Brochure, 4 pp. Describes the methods used, materials, dimensions and tolerances. All-metal Screw Prod Co, Inc, 821 Stewart Avenue, Garden City, LI, NY.

(D-54) Centrifugal Castings—Bulletin, 8 pp. Charts, comparative specifications, chemical analyses and minimum physical properties of nonferrous alloys. Illustrates and describes applications and advantages of centrifugally cast parts and assemblies. Centrifugally Cast Products Div, The Shenango Furnace Co, Dover, Ohio.

(D-55) Pressed Metal Shapes—Catalog, 24 pp. Drawings and dimensions of standard metal shapes available, produced from stock die components. Circles, dishes with and without flanges, and ovals are included. Commercial Shearing & Stamping Co, Youngstown 1, Ohio.

(D-56) Metal Forming—Bulletin, 4 pp. Advantages, capabilities, examples, of three methods of shaping metal without extensive machining: upset forging, stamping, rotoforming. Commercial Shearing & Stamping Co, Youngstown 1, Ohio.

(D-57) Investment Castings—Brochure, 9 pp. Describes the microcast process of investment casting and includes alloy tables and examples of the type of parts which may be produced. Austenal Co, Div of Howe Sound Co, Microcast Products, 224 E 39th St, NY 16, NY.

(D-58) Pearlitic Malleable Castings—Brochure, 76 pp. Reference to latest data on pearlitic malleable iron castings. Includes tables, charts, illustrations. Malleable Research & Development Foundation, Box 358, Granville, Ohio.

(D-59) Zinc and Aluminum Die Castings—Brochure, 6 pp. Describes production facilities, examples of parts cast, and properties of finished castings. Advance Tool & Die Casting Co, 3760 N Holton St, Milwaukee, Wisc.

(D-60) Radiant Heat—Brochure, 21 pp. Describes the infrared radiant method of baking, drying, dehydrating, degreasing, curing, and others throughout industry. Typical installations and case histories presented. The Fostoria Pressed Steel Corporation, 1200 N Main St, Fostoria, Ohio.

(D-61) Precision Metal Stampings—Bulletin 4 pp. Engineering information on design and availability of precision stampings and deep drawn parts of various metals. Johnson and Hoffman Mfg Corp, 31 E 2nd St. Mineola, NY.

(D-62) Die Castings—Brochure, 16 pp. Illustrates and describes facilities for engineering, diemaking, casting, machining and inspection of zinc and aluminum die-castings. Dolin Corp, 605 S 21st St, Irvington 11, NJ.

(D-63) High-alloy Casting Facilities—Catalog, 98 pp. Data listed for corrosion, heat, impact and abrasion resistant alloys. Information on casting facilities, inspection equipment and various product applications. Electric Steel Foundry Co, 2141 NW 25th Ave, Portland 10, Oregon.

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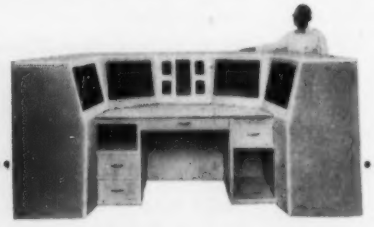

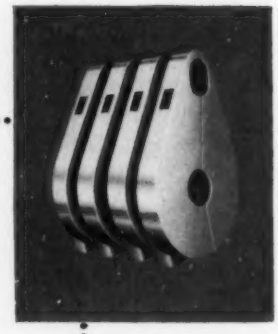

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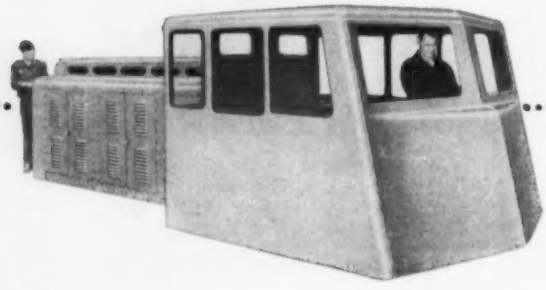

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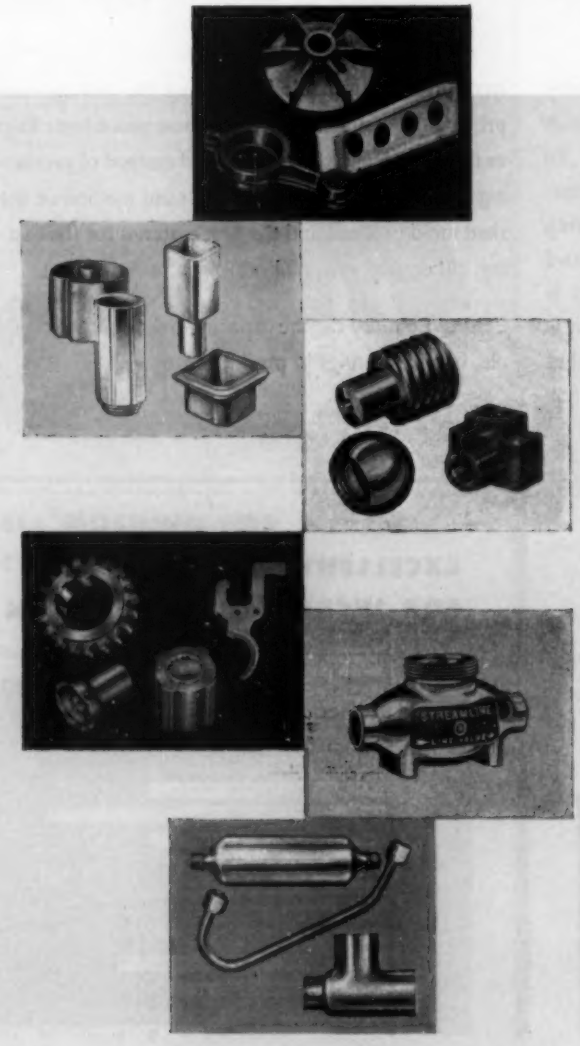

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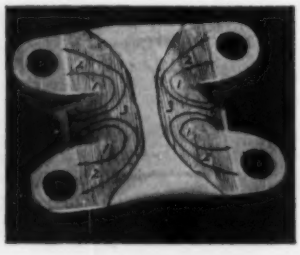
Many new developments here at Central Foundry have broadened the field of application for castings and have given design engineers greater latitude. To assist you in exploiting these new methods and materials to fullest advantage, each of our engineering departments—design, experimental, process and metallurgy—is at your disposal. Central Foundry is also using a number of testing techniques such as stress analysis, cobalt radiography and sonic testing, that have proven invaluable in lowering the cost and improving the quality of castings. These procedures help us to determine the best design and method of producing a casting, either by the green sand method or the shell mold process, and the best material for the casting, either grey iron, malleable iron or ArmaSteel.

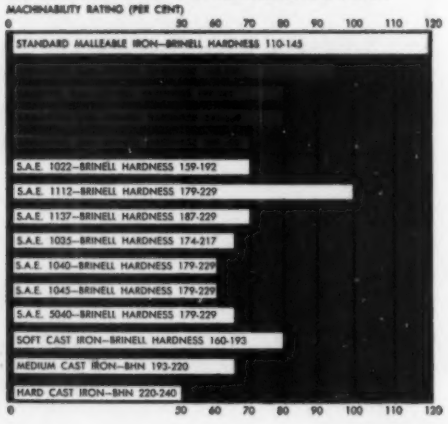
Central Foundry has the capacity to deliver, on schedule, quality castings in production quantities.

STRESS ANALYSIS FOR IMPROVED DESIGN

An important part of our engineering services is the stress analysis laboratory. Stress analysis discovers the amount of stress on a part due to its service function and is an important aid in determining and improving the strength of a part. Improved casting design can be accomplished through the use of stress-analysis by more effectively distributing the metal in the part. The U-bolt anchor plate shown here is a case in point. Our customer was experiencing failures in this part and asked us to see what we could do to solve the problem. Using stress analysis the part was completely redesigned for maximum efficiency. The redesigned part is 35% stronger, 42% lighter and less costly.



EXCELLENT MACHINABILITY FOR INCREASED PRODUCTION



CENTRAL FOUNDRY DIVISION

REDESIGN FOR STRENGTH

This is a rear spring clip pad that was converted to a casting with the help of stress analysis. The clip pad supports the shock absorber arm and clamps the spring to the rear axle of an automobile. When produced as a stamping, this part weighed 4-1/4 pounds. However, when designed as an ArmaSteel casting, weight was reduced to 2-9/10 pounds. Most important, based on comparative stress analysis tests, the casting is *30% stronger* than the stamping. (In addition, the holes are produced by the foundry, making it unnecessary for the customer to punch them.) This conversion from a stamping to a casting resulted not only in increased strength, but in substantial cost savings, as well.

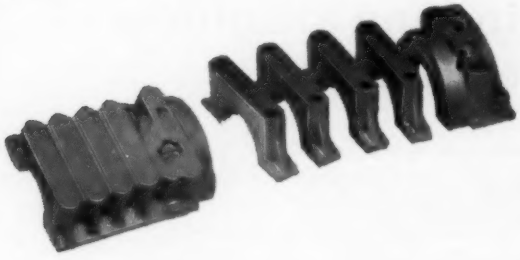
REDESIGN FOR IMPROVED PRODUCT AND ECONOMY

Many of our customers have found that redesigning a product to be made as an ArmaSteel casting rather than as a fabrication, forging or stamping, has resulted in a better part at less cost. The fabricated design of a rear wheel truck hub at the left consists of a forged base with a steel plate welded in place to form the smaller flange. The casting on the right, designed jointly by the customer and our engineers, is of single piece construction, is lighter, stronger and less costly than the fabricated design and eliminates the fitting and welding of the small flange.

FABRICATED DESIGN ARMASTEEL CASTING

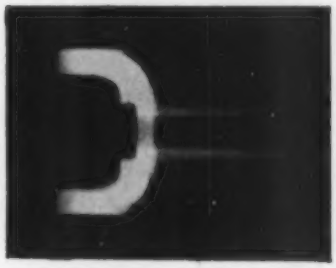
PROCESS ENGINEERING FOR LOWER COST

Our process engineers are continually looking for ways to more economically produce castings, thus lowering the finished-product cost. Shown here is a single casting that combines 5 bearing caps used on a V-8 engine. The casting is almost completely machined as a single piece, and the parts are then separated in a final operation. Substantial savings are realized in both casting and machining costs.



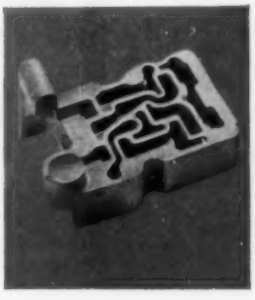
COBALT RADIOGRAPHY FOR ASSURED QUALITY

Radiography, by means of Cobalt 60, has drastically reduced the time required to check castings and is an important aid in obtaining the best possible casting quality. In an effort to eliminate a machining operation on the universal joint yoke shown here, a design change was made in the tube section of the part. When sample castings of the new design were checked radiographically, it was immediately apparent that the design was unsatisfactory since it caused acute metal feeding problems. By redesigning and further checking by radiography, Central Foundry was able to produce, in the shortest possible time, a lighter casting which required less machining in our customer's plant.



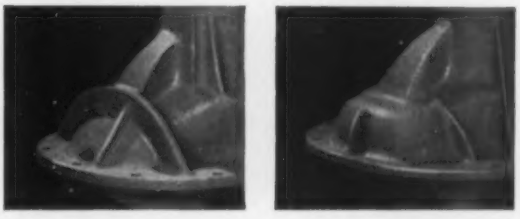
SHELL MOLDING FOR GREATER ACCURACY

Shell molding, a relatively new process of making castings, is now being employed extensively for fast, simple production of complicated castings, such as those requiring narrow, accurate passages and cross sections. It is practically impossible to produce certain parts in any other way without prohibitive costs; this is especially true of ferrous metals. Complicated parts like the manual control valve body shown here, a part of the automatic transmission of a military vehicle, are readily cast in grey iron when the shell process is utilized. The part had been considered as an aluminum die casting, but was thought unsatisfactory because of adverse expansion and wear characteristics. In this case, meeting the requirements for very close tolerances on the thickness and location of ports was made possible by the shell molding process.



REDESIGN FOR WEIGHT REDUCTION

Vehicle weight reduction is a matter of increasing importance to design engineers . . . and more and more existing parts are being converted from a low or medium to a high strength ferrous material such as ArmaSteel. On the left is a grey iron differential carrier currently used in an automobile. By taking advantage of the superior physical properties of ArmaSteel, it was possible to design the part on the right which is *five pounds lighter*. The modulus of elasticity of ArmaSteel is approximately 60% greater (the tensile strength about twice as great) than the grey iron material.



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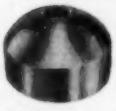

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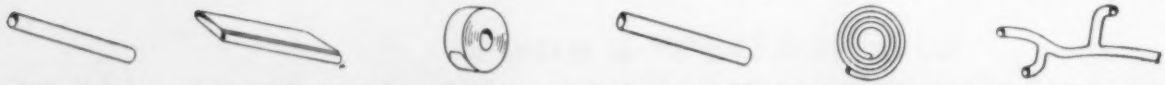

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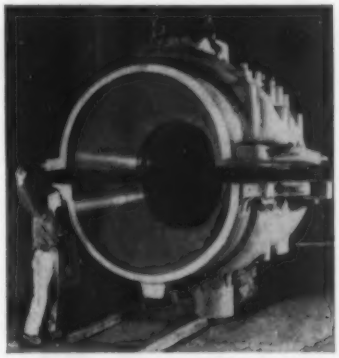
This practical design analysis, a feature of Blaw-Knox Steel Casting Service, is of invaluable assistance to designers and manufacturers. And because Blaw-Knox, itself, is one of the world's leading manufacturers of rolling mills and industrial machines, its steel foundrymen, from patternmaker to shipper, keep end-use requirements in mind every step of the way.

If you are a designer or manufacturer of a product using cast steel components, ranging from 50 pounds to 300,000 pounds, Blaw-Knox would like to send you a copy of our brochure which details the complete Blaw-Knox Steel Casting Service. Write to the Foundry and Mill Machinery Division, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.



This upper and lower cylinder blade ring for a steam turbine was cast and machined by Blaw-Knox. Weight—55,000 pounds per half.

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catalogs and bulletins.....continued

(D-64) Centrifugal Casting—Catalog, 12 pp. Advantages of designing with centrifugal castings and examples. Electric Steel Foundry Co, 2141 NW 25th Ave, Portland 10, Oregon.

(D-65) Shellcasting—Catalog, 12 pp. Advantages of designing with shellcastings. Examples shown. Electric Steel Foundry Co, 2141 NW 25th Ave, Portland 10, Oregon.

(D-66) Hydraulic Presses—Bulletin, 8 pp. Specifications of 3, 25, 40, 60, 80, 125 and 150 ton presses and their capabilities, operating characteristics and accessories. ACCO Equipment Div, American Chain & Cable Co, Inc, York, Pa.

(D-67) Hydraulic Tools—Catalog, 12 pp. Descriptions, photographs and applications of jacks, pumps, pipe benders, presses and others for use in industry and construction. Blackhawk Mfg Co, 5325 W Rogers St, Milwaukee, Wisc.

(D-68) Immersion Gold Solution—Catalog, 4 pp. Describes operating conditions, controls, and metals that may be coated. Illustrated with graphs. Engelhard Industries, Inc, 113 Astor St, Newark, NJ.

(D-69) Rubber Roll Covering—Catalog, 4 pp. Describes operations, construction features, and facilities. Raybestos-Manhattan, Inc, Passaic, NJ.

(D-70) Exhaust Duct—Bulletin, 14 pp. Illustrates use of flexible hose in fume control with prices and other information. Flexaust Co, 100 Park Ave, NY 17, NY.

(D-71) Flexible Shaft Machines—Catalog, 4 pp. Shows standard machines with attachments and full specifications. B W Elliott Mfg Co, Inc, 216 Prospect Ave, Binghamton, NY.

(D-72) Plating Process—Brochure, 18 pp. Thin coatings of tungsten carbide and aluminum oxide applied to various metals. Gives typical applications and description of process. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY 17, NY.

(D-73) Special Steel Shapes—Brochure, 12 pp. Points out the advantages and limitations of special rolled sections; irregular steel shapes, designed specifically for one purpose and rolled to the predominating cross section needed. United States Steel Corp, 525 William Penn Pl, Pittsburgh 30, Pa.

(D-74) Spinning Machine—Catalog, 26 pp. Describes features and specifications for spinning machine with forming applications. Dimensional drawings included. Meta-Dynamics Div, The Cincinnati Milling Machine Co, Cincinnati 9, Ohio.

(D-75) Injection Moldings—Brochure, 10 pp. Describes techniques recommended for nylon molding compounds. Includes information on equipment, molding conditions, coloring, and summary of molding characteristics. Plastics & Coal Chemicals Div, Allied Chemical Corp, 40 Rector St, NY 6, NY.

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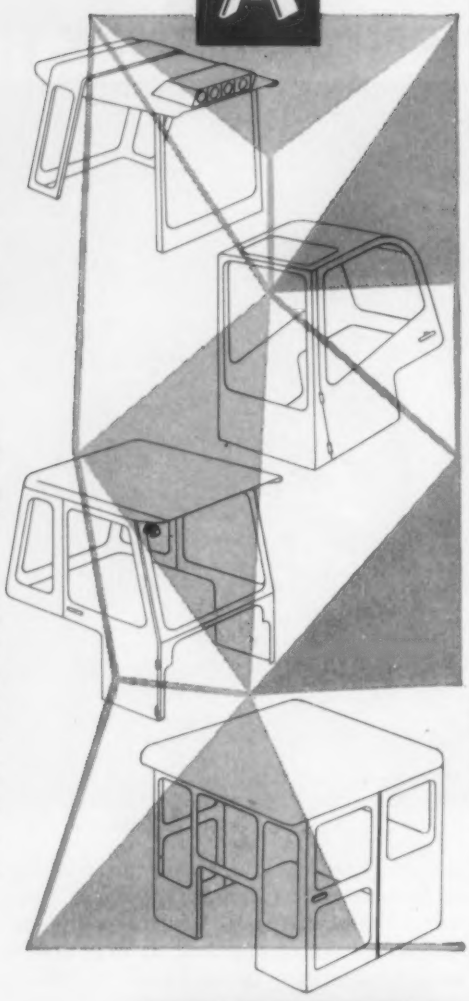

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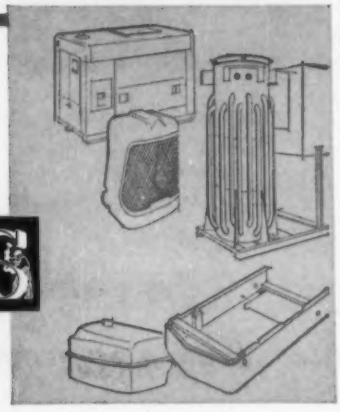

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(D-76) **Rubber and Metal Parts**—Brochure, 10 pp. Describes the type of fabrication which can be handled using rubber and metal as basic components. Also describes diaphragms for controls and instruments. Aero Gasket Corp, 763 Hanover Rd, Meriden, Conn.

(D-77) **Portable Milling Machine**—Catalog, 27 pp. Describes construction, applications, specifications, and ordering information. The Dumore Co, 1300 17th St, Racine, Wisc.

(D-78) **Investment Castings**—Brochure, 4 pp. Contains comparison chart of various casting methods, dimensional tolerances curve, finishing and assembly data. Rode, Inc, 5 Green St, Woburn, Mass.

(D-79) **Circular Rolled and Welded Products**—Catalog, 8 pp. Describes process, motor and generator frames, gear blanks, jet engine rings. Truck and tractor rims, spacer bands, and others. Cleveland Welding Div, American Machine & Foundry Co, W 117th St & Berea Rd, Cleveland, Ohio.

(D-80) **Drilling Equipment**—Catalog, 26 pp. Gives specifications, application data, engineering information, test results, and ordering information for automatic drilling equipment. The Dumore Co, 1300 17 St, Racine, Wisc.

(D-81) **Aluminum Castings**—Brochure, 40 pp. Technical description of the process, specifications and applications for variety of aluminum castings. Morris Bean & Co, Hyde Rd, Yellow Spring, Ohio.

(D-82) **Steel Castings**—Brochure, 32 pp. Reprint of a paper that covers the effects of section size and structure on fatigue properties of several cast and wrought steels. Steel Founders' Society of America, 606 Terminal Tower, Cleveland, Ohio.

(D-83) **Eyelet Attaching Machine**—Brochure, 4 pp. Automatically feeds, stakes and fuses eyelets for printed circuit boards, turret terminals, tube pins and electronic assemblies. Edward Segal, 132 Lafayette St, NY 13, NY.

(D-84) **Steel Castings**—Brochure, 12 pp. Gives chemical analyses, physical properties, sizes, production techniques and facilities available for steel castings. Industrial Div, National Malleable & Steel Castings Co, 10600 Quincy Ave, Cleveland 6, Ohio.

(D-85) **Cold Forming Machine**—Brochure, 8 pp. Outlines operating principle, advantages and applications. Used principally for internal diameters. The Cincinnati Mill Machine Co, Meta-Dynamics Div, Cincinnati 9, Ohio.

(D-86) **Drilling and Tapping Procedures**—Bulletin, 14 pp. Gives suggestions on speed of feeds, materials, lubricants, formulas and drill sizes for various alloys. Also contains information on line of automatic drills. Bedford Gear and Machine Products, Inc, 550 Krick Rd, Bedford, Ohio.

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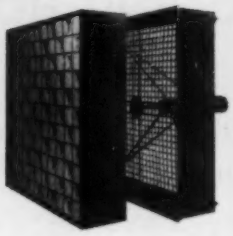

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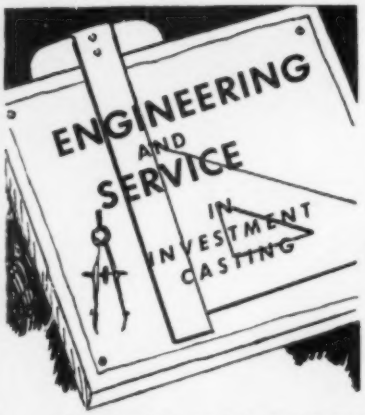

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(D-87) **Fabrication of Prototypes**—Brochure, 4 pp. Describes method of producing prototype parts. Includes illustrations of parts produced by this technique, costs and sales information. Minnesota Rubber Co, 3630 Wooddale Ave, Minneapolis, Minn.

(D-88) **Machined Centrifugal Castings**—Brochure, 8 pp. Shows typical alloys produced, foundry and machining facilities, photographs of bushings, bearings, gears, rings, and others. Wisconsin Centrifugal Foundry, Inc, 905 E St Paul Ave, Waukesha, Wisc.

(D-89) **Flame Cutting Machines**—Brochure, 18 pp. Illustrates and describes typical industrial applications, construction, operating features and accessories. National Cylinder Gas Div of Chemetron Corp, 840 N Michigan Ave, Chicago 11, Ill.

(D-90) **Power Press Brakes**—Catalog, 26 pp. Contains operations, features, capacities and dimensions of the 80, 100, 120 and 150 ton series. The Cyril Bath Co, 32400 Aurora Rd, Solon, Ohio.

(D-91) **Deep Drawing Machine**—Catalog, 20 pp. Describes principle of operation and tooling required. Also specifications and illustrations of component parts. Meta-Dynamics Div, The Cincinati Milling Machine Co, Cincinnati 9, Ohio.

(D-92) **Blast Cleaning Methods and Equipment**—Bulletin, 16 pp. Describes heavy duty construction and capacities for batch cleaning of large castings, forgings and heat treated foundry work. Describes abrasive throwing units and features. Pangborn Corp, 760 Pangborn Blvd, Hagerstown, Md.

(D-93) **Miniature Investment Castings**—Brochure, 4 pp. Describes process, tolerances, alloy selection, surface finish and features. Casting Engineers, Inc, 2323 N Bosworth Ave, Chicago 14, Ill.

(D-94) **Small Stampings**—Catalog, 38 pp. Description of facilities and engineering service; also contains listing of various types of washers, bearings, stampings and tools. Freeway Washer & Stamping Co, PO Box 1756, Cleveland 5, Ohio.

(D-95) **Turntables**—Brochure, 4 pp. Contains specifications, dimensions and capacities of all steel construction standard line. Also describes operation and typical applications. Atlas Car & Mfg Co, 1140 Ivanhoe Rd, Cleveland 10, Ohio.

(D-96) **Wire Forms and Metal Stampings**—Catalog, 84 pp. Shows typical wire forms, strip metal forms and deep drawn parts that can be made to customers' order. Eastern Tool & Mfg Co, 1 Montgomery St, Belleville 9, NJ.

(D-97) **Impact Extrusion Process**—Brochure, 30 pp. Gives weight comparisons, tensile strengths, mechanical and physical properties. Includes tables, graphs, charts and pictures. Pheoll Mfg Co, Rt 12, Michigan City, Ind.

(D-98) **Radial Draw Formers**—Brochure, 4 pp. Describes automatic continuously cycled machines for automotive body parts and mouldings. Discusses machine and die cost. The Cyril Bath Co, 32400 Aurora Rd, Solon, Ohio.

(D-99) **Spring Coilers**—Brochure, 4 pp. Illustrates hand, power, and variable speed models, equipped to coil wire .005 to .125 without the use of arbors. Ideal for making experimental and limited production springs. Perkins Machine & Gear Co, Circuit Ave, W Springfield, Mass.

(D-100) **Custom Molding**—Bulletin, 4 pp. Describes compression and transfer molding services and facilities. The Richardson Co, 2793 Lake St, Melrose Park, Ill.

(D-101) **Casting Process**—Brochure, 27 pp. Describes the use of anodizes aluminum molds to control the rate of heat transfer. Materials, cooling characteristics, design of castings, applications, graphs and drawings are also included. Niforge Corp, 677 Beacon St, Boston, Mass.

(D-102) **Vacuum Die Casting Machines**—Catalog, 15 pp. Describes and illustrates systems and machines for zinc and aluminum. Reed-Prentice Div, Package Machinery Co, East Longmeadow, Mass.

(D-103) **Tumbling Machines**—Catalog, 30 pp. Lists operations, specifications and prices of burnishing and carving machines and others. Also supplies tumbling compounds for plastic, wood and metal applications. H W Kramer Co, Inc, 120-30 Jamaica Ave, Richmond Hill 18, NY.

(D-104) **Electrical Discharge Machines**—Brochure, 4 pp. Describes features of electrical discharge method of machining and building block construction. Specifications included. The Cincinnati Milling Machine Co, Milling Machine Div, 4701 Marburg Ave, Cincinnati, Ohio.

(D-105) **Drawn Copper Shapes**—Brochure, 2 pp. Shows materials, typical shapes and facilities for production according to customer specifications. The Nippert Electric Products Co, 1759 W Mound St, Columbus, Ohio.

(D-106) **Plating Process**—Brochure, 8 pp. Describes basic coating materials, design requirements, operations and applications in aviation, electronics and others. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY 17, NY.

(D-107) **Metal Forming Methods and Machines**—Catalog, 28 pp. Describes metal case and cabinet forming machines which make flanges for enclosed shapes and compound bends. The Cyril Bath Co, 32400 Aurora Rd, Solon, Ohio.

(D-108) **Explosive Metal Fabrication**—Brochure, 9 pp. Contains description of techniques and services available for production of heat resistant, high strength materials. Table and photographs included. National Northern Div, American Potash & Chemical Corp, King St, W Hanover, Mass.

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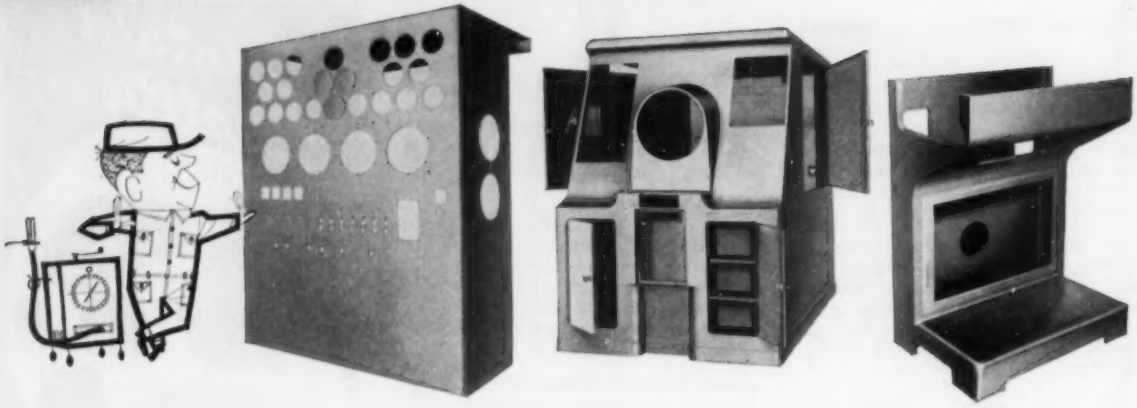

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(D-109) Sheet Metal Fabricator—Catalog, 12 pp. Describes application of machine on short run production of sheet metal hole punching and notching. Wales Strippit Inc, A Unit of Houdaille Industries, Inc, Akron, NY.

(D-110) Spindles—Catalog, 40 pp. Gives specifications, dimensions, accessories and design information for grinding, boring and milling applications. Whitnon Mfg Co, Rt 6 & New Britain Ave, Farmington, Conn.

(D-111) Upset Forgings—Brochure, 8 pp. Description of upset forgings, ¾ in. to 3 in. in diameter. Champion Rivet Co, Harvard & E 108th St, Cleveland 5, Ohio.

(D-112) Nuclear Forgings—Brochure, 6 pp. Illustrated text describes types and sizes of large and medium forgings available in carbon, alloy and stainless steel as reactor vessel components, heat exchanger shells and tube sheets. United States Steel Corp, 525 William Penn Place, Pittsburgh 30, Pa.

(D-113) Welding Methods—Brochure, 8 pp. The magnetic-flux gas shielded method of welding steel. Describes apparatus and gives production data. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY 17, NY.

(D-114) Honing Equipment—Catalog, 32 pp. Contains explanation of the honing process and its adaptability to cylindrical, spherical and flat surfaces; outlines the capacities and specifications of representative range of machines; also includes typical tools, fixtures, abrasives, coolants. Micromatic Hone Corp, 8100 Schoolcraft, Detroit 38, Mich.

(D-115) Gear Shaper Cutters—Brochure, 20 pp. Types of involute cutters, blank dimensions, tolerances, mounting methods, cutter tooth forms, sharpening and storing information. The Fellows Gear Shaper Co, Springfield, Vt.

(D-116) Cutting Machines—Catalog, 28 pp. Lists and describes oxy-acetylene devices used for straight line and circle cutting; multi-face plate-edge preparation and shape cutting. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY 17, NY.

(D-117) Internal Grinders—Catalog, 12 pp. Covers line of internal grinders and chucks for toolroom, small lot and high production hole grinding. Includes features, specifications and drawings. Bryant Chucking Grinder Co, Clinton St, Springfield, Vt.

(D-118) Stampings—Brochure, 4 pp. Describes services, tolerances and manufacturing methods. Melray Mfg Co, 9511 W River St, Schiller Park, Ill.

(D-119) Precision Metal Rolling—Brochure, 8 pp. Covers services: the rolling of metal strip to thin gauges, and close tolerances. Also lists clad metals available, properties and major uses. American Silver Co, Inc, 36-07 Prince St, Flushing, NY.

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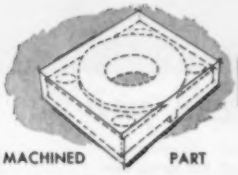

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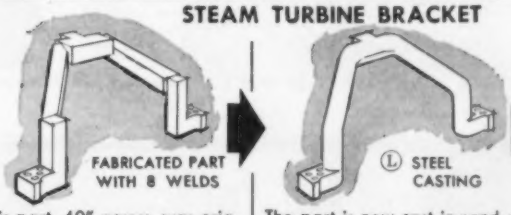

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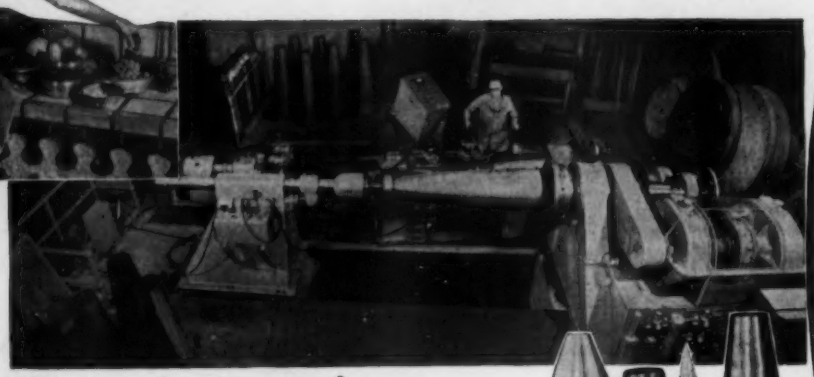

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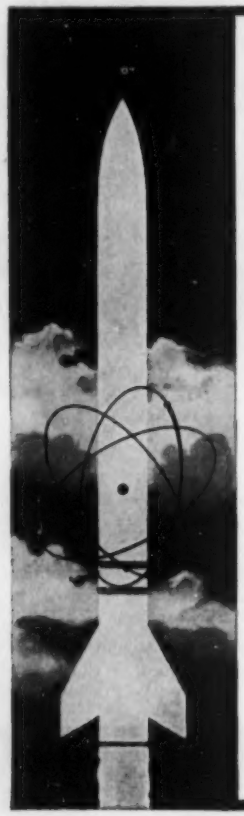

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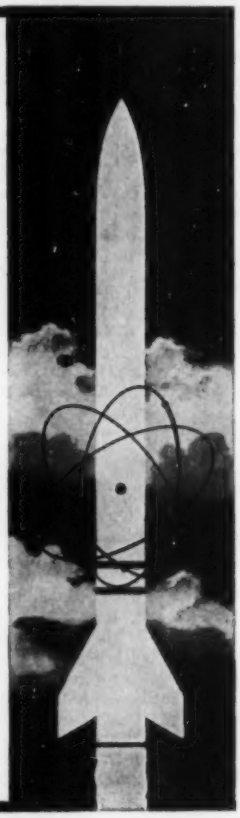

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(D-120) Investment Casting—Brochure, 4 pp. Techniques for determining proper casting design, production method, correct cost elements, and satisfactory selling price. Misco Precision Casting Co, 112 Gibbs St, Whitehall, Mich.

(D-121) Vibrators and Feeders—Catalog, 28 pp. Technical data and installation procedures for pneumatic and electric vibrators and feeders in diversity of applicating. The Cleveland Vibrator Co, 2828 Clinton Ave, Cleveland, Ohio.

(D-122) Roll Formed Shapes—Bulletin, 8 pp. Illustrations of various roll formed shapes used as functional and decorative sections and their specific applications. Roll Formed Products Co, 3756 Oakwood Ave, Youngstown, Ohio.

(D-123) Injection Molding—Brochure, 8 pp. Describes the basic molding techniques and part design requirements for producing injection molded items from high density polyethylene plastic. W R Grace & Co, Polymer Chemicals Div, 225 Allwood Rd, Clifton, NJ.

(D-124) Steel Blades—Bulletin, 8 pp. Describes manufacture and application of composite and solid steel shear blades, tube cut-off blades, rotary slitting knives and spacers, liner and rocker plates, pressure blocks, and hardened rolls. The Ohio Knife Co, Dept B-92, Cincinnati 23, Ohio.

(D-125) Small Zinc Die Castings—Bulletin, 8 pp. Guide to the design possibilities of tiny die castings. Tabulates design criteria, specifications and compares common production methods for small parts. Check list of design practices is included. Gries Reproducer Corp, 125 Beechwood Ave, New Rochelle, NY.

(D-126) Abrasives for Grinding—Brochure, 28 pp. Describes grinding techniques on alloy, high-speed and die steels. Also discusses aluminum oxide abrasives, wheel shapes and markings, mounted wheels, sticks, stones, rubs and grading recommendations. The Carborundum Co, Dept PE, PO Box 337, Niagara Falls, NY.

(D-127) Metal Moldings and Alloy Tubing—Catalog, 100 pp. Describes applications, facilities, standard sizes and dimensions. Also provides drawings of various shapes. Metal Forming Corp, Div of Vanadium-Alloys Steel Co, Elkhart, Ind.

(D-128) Wire and Strip Construction—Bulletin, 24 pp. Gives steel wire sizes, comparison of gages, electric spot welding facilities, plating and finishing processes. Wire diameters from $\frac{1}{32}$ in. to $\frac{1}{8}$ in. can be formed with automatic machinery. Photographs of typical wire end treatments. E H Titchener & Co, 67 Clinton St, Binghamton, NY.

(D-129) Wire Stitching—Catalog, 28 pp. Box stitching, bagging, labeling and metal stitching are shown in typical applications. Includes specifications and photographs. Acme Steel Co, 135th St & Perry Ave, Chicago 27, Ill.

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(D-130) Heat Treating Facilities—Brochure, 50 pp. Details the tools, gears, precision lapping and heat treating facilities for research, design and manufacture of precision force control components. Sargent Engineering Corp, 2533 E 56th St, Huntington Park, Calif.

(D-131) Hand Tools—Catalog, 60 pp. Describes construction, specifications, purpose and dimensions. Also contains selection guide and standards for wrench and socket sizes. Herbrand Div, The Bingham-Herbrand Corp, Fremont, Ohio.

(D-132) Aluminum Building Sheet—Brochure, 4 pp. Describes baked enamel finished aluminum building sheet. Offers color chips and suggested applications. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19, Pa.

(D-133) Molded and Extruded Rubber Parts—Brochure, 6 pp. General comparison of rubbers in physical properties and environmental influences; operational capacities, colors, mold and die designs are described and illustrated. The Garlock Packing Co, 402 Main St, Palmyra, NY.

(D-134) Tube Forming—Catalog, 41 pp. Contains description of configurations, manufacturing facilities and processes, dimensions, drawings and photographs. Aeroquip Corp, 300 S East Ave, Jackson, Mich.

(D-135) Welded Assemblies—Catalog, 60 pp. Contains pictures of various welded precision assemblies and description of construction. Includes rings and bands. American Welding & Mfg Co, 103 Dietz Rd, Warren, Ohio.

(D-136) Rolled Metal Shapes—Catalog, 100 pp. Rolled shapes shown in actual size illustrations. Welded alloy tube from ¼ in. od by .020 in. to 3½ in. od by .125 in. Metal Forming Corp, Div Vanadium-Alloys Steel Co, 1937 Sterling Ave, Elkhart, Ind.

(D-137) Ultrasonic Impact Grinding Equipment—Catalog, 12 pp. Describes principles of operation and gives specifications. Raytheon Mfg Co, Industrial Apparatus Div, 100 River St, Waltham 54, Mass.

(D-138) Casting Methods—Catalog, 160 pp. Describes pictorially and with text the methods used in sand mold, resin-sand shell mold, permanent mold, and investment casting methods. Compares general design rules. Howard Foundry Co, 1700 N Kostner Ave, Chicago 39, Ill.

(D-139) Deep Drawn Closures—Catalog, 72 pp. Gives description of standard can sizes, ordering information, material specifications, and covers for application in the electronics industry. Hudson Tool & Die Co, Inc, 18 Malvern St, Newark, NJ.

(D-140) Silicon Carbide—Bulletin, 4 pp. Gives the fabrication data, applications, chemical, electrical and nuclear properties of silicon carbide. The Carborundum Co, Dept PE, Research and Development Div, Niagara Falls, NY.

(D-141) Molding and Potting Services—Brochure, 17 pp. Describes epoxy resin encapsulation, special potting and hermetic sealing compounds. Includes prices, mold design, compound selection and formulation data. Bacon Industries, Inc, 192 Pleasant St, Watertown, Mass.

(D-142) Electrostatic Hand Gun—Brochure, 4 pp. Describes spraying process used to coat metallic and nonmetallic materials. Consists of voltage pack, atomizer and paint gun. Installation requirements and operational technique are covered. Ransburg Electro-Coating Corp, PO Box 23122, Indianapolis 23, Ind.

(D-143) Automatic Drilling and Tapping Units—Brochure, 8 pp. Description, dimensional data, and examples of typical installations. The Govro-Nelson Co, 1931 Antoinette St, Detroit, Mich.

(D-144) Deep-drawn Metal Stampings—Brochure, 6 pp. Explains advantages of stampings; illustrates typical large and medium size drawn stampings; describes drawing and porcelain enameling facilities. Geuder, Paeschke & Frey Co, 324 N 15th St, Milwaukee 1, Wisc.

(D-145) Special Tooling—Brochure, 15 pp. Describes design procedures, cost analysis methods, engineering and manufacturing facilities for production of special machinery, tools and dies. Centerline, Inc, 29700 Euclid Ave, Wickliffe, Ohio.

(D-146) Cold Drawn Shapes—Catalog, 12 pp. Contains description of process, available materials and design considerations for pinions and gears, machining procedures, typical applications and ordering data. Includes tables of proportions, speeds, machinability ratings and material constants. Rathbone Corp, 241 Park St, Palmer, Mass.

(D-147) Hot-extruded Steel Forgings—Bulletin, 5 pp. Shows typical shapes and discusses metal strength of the contour grain flow type. Materials to which process applies range from mild steel to precipitation hardening austenitic steel. Thompson Products Valve Div, Thompson Ramo Wooldridge Inc, 1455 E 185th St, Cleveland 10, Ohio.

(D-148) Hydroforming Method—Brochure, 8 pp. Describes the hydroforming method of deep drawing metals; savings in tooling costs and applications. Explains custom service available. Hydroforming Co of America, Inc, 7400 W Lawrence Ave, Chicago 31, Ill.

(D-149) Electrostatic Spray Painting—Brochure, 16 pp. Covers operation, necessary equipment, power requirements, applications and advantages of spray painting equipment. Ransburg Electro-Coating Corp, PO Box 23122, Indianapolis 23, Ind.

(D-150) Metalworking Machines—Catalog, 12 pp. Specifications and capacities of benders, rod parters, punch presses, shears, rollers, and others. O'Neill-Irwin Mfg Co, 425 Eighth Ave, Lake City, Minn.

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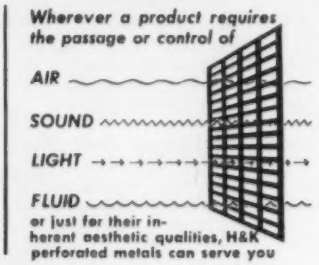
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(D-151) **Centrifugal Castings**—Brochure, 16 pp. Presents data on casting process, physical and chemical properties, charts, typical military and ASME code approved specifications and production capacities for various applications. Sandusky Foundry and Machine Co, Sandusky, Ohio.

(D-152) **High-speed Index Tables**—Catalog, 16 pp. Includes load ratings, dimensions, dial sizes from 12 in. to 120 in., with 4 to 24 stations and 90 to 270 degree indexing periods. Right angle drives, gear reducers and power assemblies are shown. Ferguson Machine Corp of Indiana, 7818 Maplewood Industrial Court, St. Louis 17, Mo.

(D-153) **Forgings, Bushings and Springs**—Catalog, 24 pp. Shows facilities for upset and drop forgings, weldments and fabricated components. Includes photographs and tool lists. Hammond Div, American Steel Foundries, Prudential Plaza, Chicago 1, Ill.

(D-154) **Aluminum Tool Plate**—Brochure, 16 pp. Specifications, standard sizes, properties, fabricating techniques and typical end uses are given for direct chilled aluminum tooling plate. Pioneer Aluminum Inc, 5251 W Imperial Hgy, Los Angeles, Calif.

(D-155) **Bronze and Copper Centrifugal Castings**—Brochure, 8 pp. Contains nominal analysis, physical properties and typical applications of brass bronze and copper alloys. National Bearing Div, American Brake Shoe Co, PO Box 458, Meadville, Pa.

(D-156) **Power Actuated Tools**—Catalog, 8 pp. Describes tool models and drivepins, giving their operation, dimensions and suggested applications. Omark Industries, Inc, 9701 SE McLoughlin Blvd, Portland, Oregon.

(D-157) **Aluminum and Magnesium Castings**—Catalog, 20 pp. Shows facilities, quality control and production methods; lists chemical and physical properties of various aluminum and magnesium alloys. The Wellman Bronze & Aluminum Co, 12800 Shaker Blvd, Cleveland 20, Ohio.

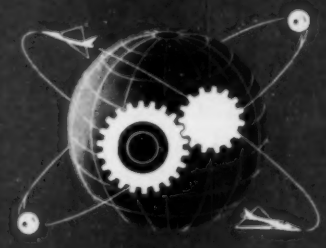
(D-158) **Impact Extrusions**—Catalog, 16 pp. Contains description of production methods, alloy selection tables, dimensional tolerances and application data on typical extruded parts. Mueller Brass Co, Port Huron, Mich.

(D-159) **Pearlitic Malleable Iron Castings**—Brochure, 12 pp. Gives physical properties, machinability rating, milling, broaching and heat treating are covered. Includes charts, typical applications and photographs. Central Foundry Div of GMC, 37 Florence St, Saginaw, Mich.

(D-160) **Investment Castings**—Brochure, 7 pp. Describes tolerances, corrosion and heat resistance of small intricate parts. Photographs, typical casting problems and solutions. Vascoloy-Ramet Corp, Waukegan, Ill.

SECTION E

POWER TRANSMISSION



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DESIGN ABSTRACTS

THREE BASIC DRIVES

Performance features of three basic power transmission drive devices—clutch, fluid coupling, hydraulic torque converter—are reviewed. Output-performance characteristics, rather than specific design features, are compared. It will be seen that no particular type of drive is categorically superior to others. The performance requirements and operating conditions of the driven machinery and the prime mover must be analyzed before a drive is selected.

Clutch

The common friction clutch will transmit full power mechanically from the prime mover to the power-train member immediately behind the clutch. There should be no loss of torque or speed once the clutch is fully engaged, unless the slip torque of the clutch is exceeded.

Fluid Coupling

The fluid coupling will transmit full torque from the input member to the output member through its hydrodynamic circuit. There will be some loss of speed, dependent upon the torque being transmitted, due to the slip which is inherent in the hydrodynamic circuit.

Hydraulic Torque Converter

The hydraulic torque converter will give variable-torque transmission, depending upon the load on its output member. Although the clutch and the fluid coupling cannot multiply the torque from the prime mover, the hydrodynamic circuit of the torque converter can multiply the torque absorbed by its input member.

"Clutch — Fluid Coupling — Hydraulic Torque Converter . . . Application Considerations and Performance Comparisons," R W Bachmann, Twin Disc Clutch Co; ASME paper no. 59-MD-6, ASME, 29 W 39th St, New York 18.

*

Wet Type Clutches

This paper contains a mathematical analysis of clutch engagement under certain idealized conditions and a presentation of some related experimental work. For the sole purpose of discussion, the theoretical clutch engagement analysis has been divided into several cases. Some of these cases are not necessarily drawn from a set of practical applications, but all serve to establish a basis for viewing the interrelationship of the various parameters.

"Engagement Characteristics of Wet Type Clutches," L P Ludwig, Twin Disc Clutch Co; SAE paper no. 76B, SAE, 485 Lexington Ave, New York 17.

*

Characteristics of the Three-Lobe Bearing

An analytical solution of 3-hole journal bearings is offered based on the solution of the finite Reynolds equation. Expressions for eccentricity, lubricant flow, power loss, and spring constant are given for a range of L/D ratios and ellipticities. The bearing is shown to be of superior quality both in its stability characteristics and in its hydrodynamic performance. Charts and equations for setting design requirements and calculating performance are given in simple convenient form.

"Analysis and Characteristics of the Three-Lobe Bearing," O Pinkus, General Electric Company, ASME paper no. 58-LUB-2, ASME, 29 W 39 St, New York 18.

*

Drives for High-Mach Aircraft

The increased requirement for a-c electrical power with closely regulated frequency in high-Mach aircraft dictates the need for high performance constant-speed drives. Hydraulic variable-speed transmissions are particularly adapted to provide the fast response and close speed control required in these devices. This paper describes the characteristics of the components utilized in constant-speed drives and some of the technical problems and their solutions in assembling these components into complete speed drive systems. Examples of actual hardware and test results are given.

"Constant Speed Drives for High Mach Aircraft," F L Moncher and J S Cardillo, Vickers Inc; SAE paper no. 94C, SAE, 485 Lexington Ave, New York 17.

*

Heavy-duty Transmissions —What's Coming

The character of the heavy duty transmissions of the future will be greatly influenced by the economic trend—what the industry can afford.

If substantial increases in horsepower can be tolerated, and the power-to-weight ratio increased so that considerable improvement in vehicle performance is gained, then the multi-speed transmission as we now know it will be replaced with something of less complexity and fewer ratios.

"What is to Come in Heavy Duty Transmissions —Mechanical—Automatic," Larry Flynn, GMC no. 73B, SAE, 485 Lexington Ave, New York 17.

*

Gear Tolerances

Admitted that there is room for better methods of specifying the precision of gears. But just what's the best approach to the problem?

As a service to readers, PRODUCT ENGINEERING recently presented an article, "New Standards for Gears Span Wide Range of Quality." It proposed doubling the number of AGMA classes to include an "ultra-precise" group of gears which the author, L. D. Martin, considered of growing importance. Mr. Martin is chairman of the ASA Subcommittee on Fine Pitch Gears, and member of three AGMA committees; his article

(Dec 22 '58, p 46) aroused considerable discussion.

This present article by a prominent gear manufacturer offers a counter-proposal to Mr. Martin's plan. Mr. Wiegand believes the need for ultra-precision hasn't arrived yet and additional classes will only add to the confusion. He goes on to offer an approach to what he says gear designers really want—tables that directly give shaft-center distances and backlash values for each present class of gears.

Mr. Wiegand will be remembered for his article, "7 Rules Simplify Instrument Gear Specification," Nov 25 '57, p 80, which recommends holding requirements to a minimum. Readers who want a comprehensive analysis of the AGMA standards will find it in George Michalec's article, "Methods of Specifying Precision of Spur Gears," Nov '56, p 135.

"A Workable Approach to Gear Tolerances," William A. Wiegland, Dynamic Gear Co; Product Engineering, May 25, '59, 330 W 42nd St, New York 36.

*

Cylindrical Journal Bearings

The knowledge of hydrodynamic damping and elastic properties of journal bearings is desirable for the accurate determination of the critical speed of a shaft and for the anticipation of its behavior in the neighborhood of such speeds. It is also required for judging the stability of the rotating shaft against self-excited vibrations.

"Elastic and Damping Properties of Cylindrical Journal Bearings," B Sternlicht, General Electric Co; ASME paper no. 58-LUB-3, ASME, 29 W 39 St, New York 18.

*

Replace Gears by Mechanisms

A practical method is shown for designing four-bar mechanisms having a prescribed transmission ratio held within prescribed tolerances, for a limited range of motion. Such mechanisms may economically replace gears in many applications. Charts enable the designer to choose the mechanism having the best transmission angle possible.

"How to Replace Gears by Mechanisms (Linkages)," Kurt Hain and Gerhard Marx, Institut for Landtechnische Grundlagenforschung der Forschungsanstalt fur Landwirtschaft, ASME paper no. 58-SA-33, ASME, 29 W 39 St, New York 18.

*

Gear Lubrication

The paper is a brief review of the research on fundamentals of gear lubrication performed at Shell Development Company for the Bureau of Aeronautics of the Department of the Navy. It is constructed along the following lines: Scoring and wear of gears are evaluated as functions of various operating variables, gear geometry and construction factors, and lubricants properties. This is followed by a brief discussion of the results of experiments performed with tagged extreme-pressure lubricants showing distribution and thickness of the extreme-pressure films and the rates of their attrition. Based on all these results, a mechanism of gear lubrication is postulated and discussed.

"On the Mechanim of Gear Lubrication," V N Borsoff, Shell Development Co; ASME paper no. 58-LUB-4, ASME, 29 W 39 St, New York 18.

*

Gear Analysis

The design and fabrication of precision gears has led to the development of two parameter specifications, total composite error (TCE) and angular position error, which are essential for proper designation and fabrication. The TCE parameter is very widely used and is equally well understood. Angular position error specification is a more recent development, is still limited to areas of high precision, and is not widely understood. Both parameters are significant and must be properly comprehended in order to adequately engineer a gear.

Position Error

Angular position error is sometimes called index error, but recently committees of the American Gear Manufacturers Association (AGMA) indicate a preference for the term angular position error. However, because angular position error is related to gear size (i.e., pitch radius) a more universal term is merely "position error". This is a general designation in that it equally applies to angular and linear values, and as a linear value allows for direct comparisons without requiring the correlation with gear size.

This paper defines TCE and position errors, shows their relationship and interaction, and indicates the conditions which make each particularly significant. It is hoped there will result a wider understanding of position error and its relation to TCE and a step towards standardization in the use of the term "position error" and its variation "angular position error".

"Analysis and Comparison of Total Composite Error and Position Error in Gears," George W Michalec, General Precision Laboratory Inc; AGMA paper no. 239.07, AGMA, One Thomas Circle, NW, Washington 5, D C.

*

Circular Step Bearing

Equations relating the flow of the lubricant and the axial motion of an externally pressurized thrust bearing are developed. The bearing is shown to be stable when the fluid is incompressible.

Expressions for local stiffness and damping coefficients, useful in the evaluation of the dynamic response of the bearing, are given.

"Axial, Relative Motion of a Circular Step Bearing," L Licht, The Franklin Institute Laboratories; ASME paper no. 58-LUB-1, ASME, 29 W 39 St, New York 18.

E POWER TRANSMISSION

DESIGN OF Nylon Resin Spur Gears

From: ASME paper

K. W. HALL, Professor
H. H. ALVORD, Associate Professor
University of Michigan

Method of calculating the load-carrying capacity of gears of Zytel nylon resin. Design recommendations are given and design charts to establish torque capacity or gear size to transmit a given torque.

A thermoplastic material, Zytel is supplied in the form of granulated powder from which many articles can be molded by conventional molding techniques. Molded material has relatively light weight, is rigid and tough, has low coefficient of friction, and good resistance to abrasion. Zytel is made in several nylon molding powder compositions, of which Zytel 101 is recommended for mechanical parts.

Physical properties are affected by temperatures; yield strength decreases with increase in temperature, while impact strength increases. Moisture content of the molded material also affects properties. Material used is conditioned to have 2½% moisture by weight, equivalent to 50% relative humidity and 73 F.

Besides the load-carrying ability of gear teeth, the design recommendations of Table I are based on test information and investigations with gears of Zytel nylon resin.

GEARS TESTED

Gear testing machines ran with two pair of gears loaded against each other. In this way the driving motor supplied only the power to overcome friction and windage.

Tooth load is applied by twisting a torsion bar which connects the gear shaft. Lead shot in buckets is used as weight, thus permitting any desired amount of twist by changing the amount of shot in the buckets. Test machine is driven by a constant-speed motor through a speed variator, giving a 600 to 5000 rpm speed range. Oil mist lubrication is used, which is shut off for dry gear runs.

Gears were machined from molded disks of Zytel. Teeth were cut with hobs after the disks had been machined to size. Pitch diameters ranged from 1.375 to 3.75 in., with diametral pitches of 16, 20, 32 and 48.

In addition to the cut gears, 2½ in. dia, 20 pitch and 32 pitch molded teeth gears were tested. They have a 20° pressure angle, full-depth teeth and ½ in. face width. A ⅛ in. web joins the hub and rim.

TESTS AND RESULTS

An extensive life testing program was first conducted with the machined gears having cut teeth, so that variations in gear diameter, diametral pitch, face width, pressure angle, and others, could be more easily accomplished. Pitch line velocities ranged from 785 to 3730 fpm, both with and without lubrication of the teeth. Tests were made with pairs of identical gears running together, and with small pinions in contact with larger

Table I–Some Design Recommendations for Zytel Gears

Size of teeth, as with metal gears, should be the smallest possible which are capable of transmitting the necessary power. Limitations of the load-carrying calculations should be considered when determining teeth size.

Pressure angle and tooth form best suited for the nylon resin are full-depth teeth with a 20° pressure angle. Full-depth teeth may be strengthened by making the blank oversize, but care must be exercised as strength gained by the thicker base may be offset by the weakening effect of higher temperature caused by increased normal force and sliding velocity.

The 16-pitch, 27-tooth, 20° pressure angle gears made with ⅛ in. oversize blank diameters had greater strength than the same gear with standard full-depth teeth. Similar gears with 20° and 30° stub teeth had less life than the standard full-depth teeth.

Backlash must be provided, but performance does not seem to be affected by reasonable variations in backlash. Recommended values measured at room temperature: 16 diametral pitch, 0.004 to 0.006 in.; 20 DP, 0.003 to 0.005 in.; 32 and finer, 0.002 to 0.004 in. For high speed or very heavy load operation which may heat the teeth, backlash should be increased to compensate.

Gear proportions, rims, webs, and hubs should be generously proportioned to give ample support for the teeth. This is important for heavily loaded teeth.

In general, the rim thickness beneath the root of the teeth should be at least 3 times the thickness of the teeth at the pitch circle; web thickness should be about equal to the rim thickness; hub diameter at least 1½ times the shaft diameter; and the hub length at least equal to the shaft diameter.

If the gear is large and the teeth heavily loaded, the Zytel gear should be mounted on a metal flange rather than key or spline the gear directly to the shaft.

Molded gears should be designed to reduce or eliminate the formation of residual stresses, and the mold should have a ring gate to maintain concentricity.

Treatment after molding includes a full anneal if there is any evidence of residual stresses being present. It is better to design the gear to prevent formation of these stresses, rather than to rely on annealing, as annealing may affect the teeth accuracy if the residual stresses are not uniformily distributed.

gears. Ambient temperature and humidity were not controlled. Temperature varied from 68 to 92 F; relative humidity from 29 to 85%.

Results obtained with cut teeth gears are shown in Figs. 1 and 2. Similar but less extensive data were obtained for 20 and 40-pitch gears.

Results obtained with molded teeth are shown in Figs. 3 and 4. Some had been tested as molded; some had been moisture conditioned; and some were annealed. Fig. 4 indicates that the life of 32 pitch molded gears is greater at any given load than of gears with cut teeth. Fig. 3, however, does not show this same increase in life.

One reason advanced for the low values of the 20-pitch molded teeth, particularly in the higher stresses, was the presence of residual stresses in the rim of most of the molded gears, and the thin web which did not give enough support for the rim and teeth at high loads. The line of Fig. 3 is drawn to represent the test results obtained with annealed gears. Annealed gears will fail at the root in a typical fatigue failure.

At higher loads there was evidence of web distortion in the 20-pitch gear, and this probably adversely affected the life of the molded gears. Nevertheless, molded teeth are an improvement over cut teeth in the sizes tested and probably in 16 and 48-pitch molded gears as well. Thus, Fig. 5, which establishes the allowable stress curves includes the 16 and 48-pitch.

Table II—Tooth Form Factor Y for Load Near Pitch Point

Number of Teeth	20° Full-Depth Form	20° Stub-Depth Form
15	.....	0.556
16	.....	0.578
17	.....	0.587
18	.....	0.603
19	.....	0.616
20	0.544	0.628
22	0.559	0.648
24	0.572	0.664
26	0.588	0.678
28	0.597	0.688
30	0.606	0.698
34	0.628	0.714
38	0.651	0.729
43	0.672	0.739
50	0.694	0.758
60	0.713	0.774
75	0.735	0.792
100	0.757	0.808
150	0.779	0.830
300	0.801	0.855
Rack	0.823	0.881

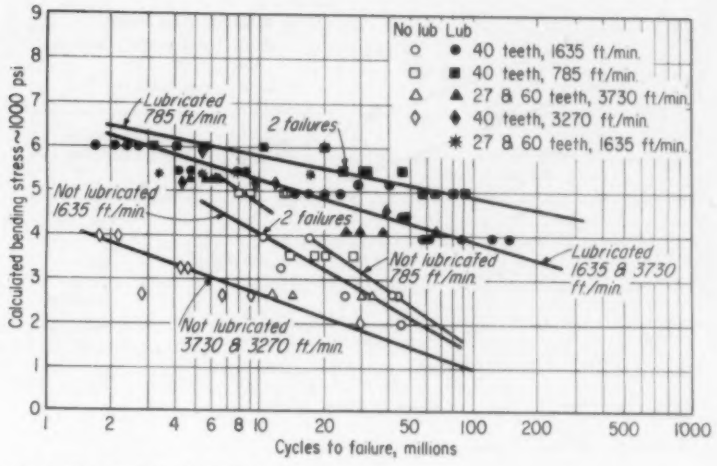

Calculated bending stress~1000 psi
Cycles to failure, millions
No lub Lub
40 teeth, 1635 ft./min.
40 teeth, 785 ft./min.
27 & 60 teeth, 3730 ft./min.
40 teeth, 3270 ft./min.
27 & 60 teeth, 1635 ft./min.
Lubricated 785 ft./min.
2 failures
Not lubricated 1635 ft./min.
2 failures
Not lubricated 785 ft./min.
Lubricated 1635 & 3730 ft./min.
Not lubricated 3730 & 3270 ft./min.

Fig. 1—Fatigue life of 16-pitch cut gear teeth.

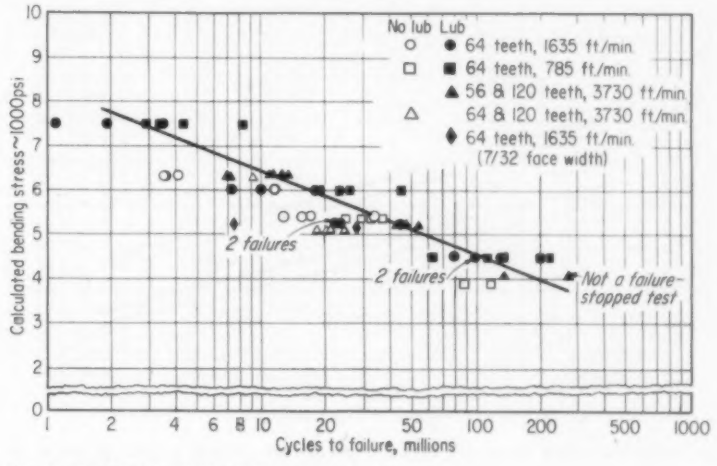

Calculated bending stress~1000psi
Cycles to failure, millions
No lub Lub
64 teeth, 1635 ft./min.
64 teeth, 785 ft./min.
56 & 120 teeth, 3730 ft./min.
64 & 120 teeth, 3730 ft./min.
64 teeth, 1635 ft./min. (7/32 face width)
2 failures
2 failures
Not a failure-stopped test

Fig. 2—Fatigue life of 32-pitch cut gear teeth.

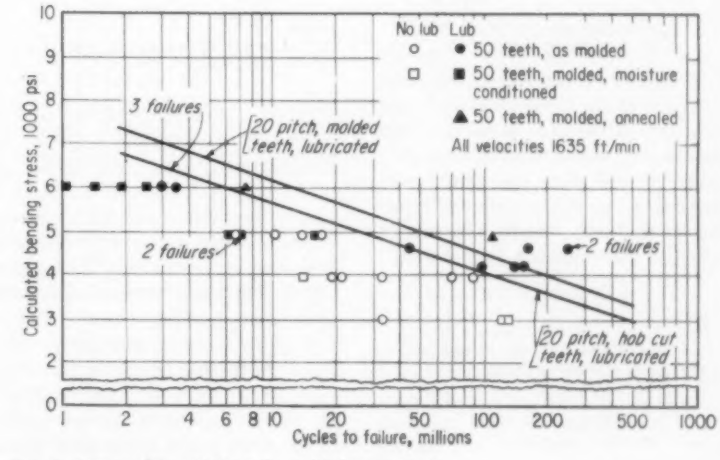


Fig. 3—Fatigue life of 20-pitch molded gear teeth.

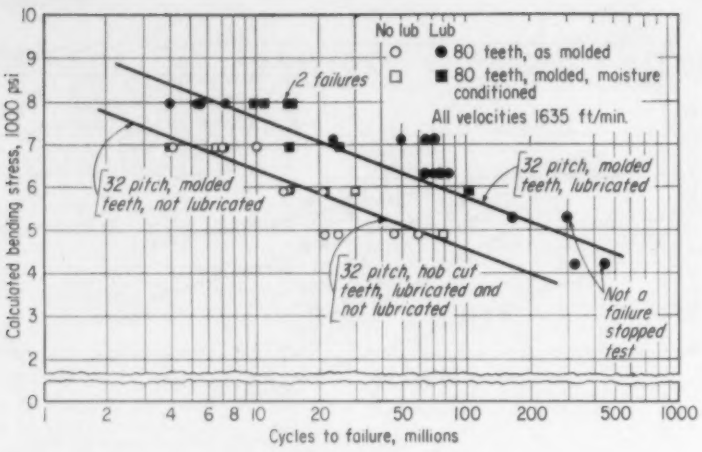

No lub Lub
80 teeth, as molded
80 teeth, molded, moisture conditioned
All velocities 1635 ft/min.
2 failures
32 pitch, molded teeth, not lubricated
32 pitch, molded teeth, lubricated
32 pitch, hob cut teeth, lubricated and not lubricated
Not a failure stopped test
Calculated bending stress, 1000 psi
Cycles to failure, millions

Fig. 4—Fatigue life of 32-pitch molded gear teeth.

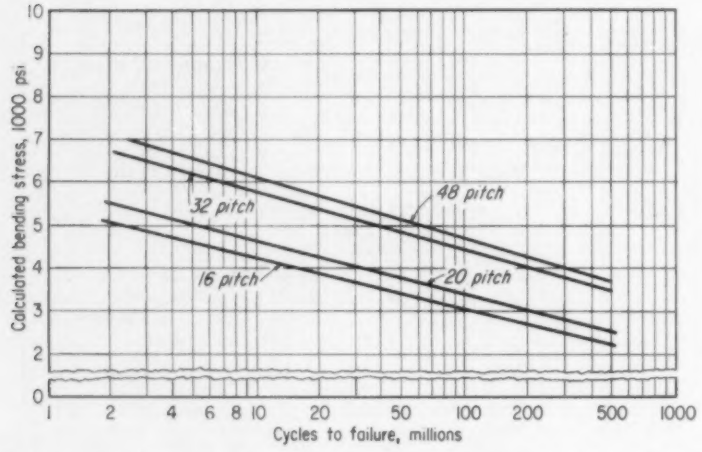


Fig. 5—Recommended maximum allowable stresses for molded Zytel gear teeth, 20° pressure angle, full-depth, oil lubricated for the indicated pitch gears.

LOAD-CARRYING CAPACITY OF GEARS OF ZYTEL

The Lewis equation which was used to calculate the stresses in the gear teeth can also be used to calculate the load-carrying capacity of the teeth by using the test data to establish the allowable stresses. However, this equation is more useful when rewritten in either of the following forms:

$$T = SDFYK/2P$$

where
T = torque gear can transmit, lb-in.
S = allowable stress, psi, from Fig. 5
D = pitch diameter of pinion, in.
F = face width, in.
Y = form factor for pinion, Table II
K = design factor, Table III
P = diametral pitch

or

$$HP = SDFYNK/126{,}000P$$

where
HP = horsepower gear can transmit
N = pinion speed, rpm

What are considered to be the maximum recommended stresses for molded and lubricated teeth are shown in Fig. 5. To give a margin of safety, the lines have been reduced 25% from the represented failure of the gears on test. Fig. 5 indicates higher allowable stresses for small teeth than for large teeth. Reason: load is distributed among more teeth when the teeth are small, even though the method of calculation considers the entire load to be carried by one tooth. Also, larger teeth tend to run at a higher temperature than the smaller teeth, which has the effect of weakening the larger teeth.

Table III—Values of Design Factor K for Use With Lewis Equation and Design Charts

Teeth	Lubrication	Velocity ft/min	Pitch	Factor K
molded	yes	below 4000	16–48	1.00
molded	yes	above 4000	16–48	0.85
molded	no	below 1635	16–20	0.70
molded	no	above 1635	16–20	0.50
molded	no	below 4000	32–48	0.80
cut	yes	below 4000	16–48	0.85
cut	yes	above 4000	16–48	0.72
cut	no	below 1635	16–20	0.60
cut	no	above 1635	16–20	0.42
cut	no	below 4000	32 48	0.70

Curves of Fig. 5 show the maximum stresses which should be used when the load is reasonably steady with virtually no shock or impact loading. These should be used with judgment, and reduced to compensate for overloading, impact or shock loading, or other conditions of operation that may be present in the design.

Design factor, K, Table III, compensates for designs using cut rather than molded teeth, for lack of lubrication, and for velocities in excess of 4000 rpm. Other than this no correction need be made for velocity.

It is possible to approximate allowable stresses for pitches other than shown in Fig. 5. However, approximation of stresses for gears with teeth much larger than tested should not be attempted. The combination of large loads and high sliding velocities may exceed some limiting value not reached with the present test. For example, the teeth may fail by surface deterioration rather than by bending fatigue. Here, load-carrying capacity would be limited by resistance to wear rather than by bending fatigue.

Teeth having pitches finer than 48 should not be approximated using Fig. 5, unless the dimensions of the teeth are very carefully controlled. Errors could reduce the carrying capacity of such small teeth.

To facilitate the design of gear teeth of Zytel, the equations and the stresses of Fig. 5 have been combined to form the design charts of Fig. 6 (A), (B), (C) and (D). Charts can be used to establish the size of gear required to transmit a given torque. A design factor K, Table III, is used with the charts to increase the torque which must be transmitted, or to decrease the torque which the gear is capable of transmitting.

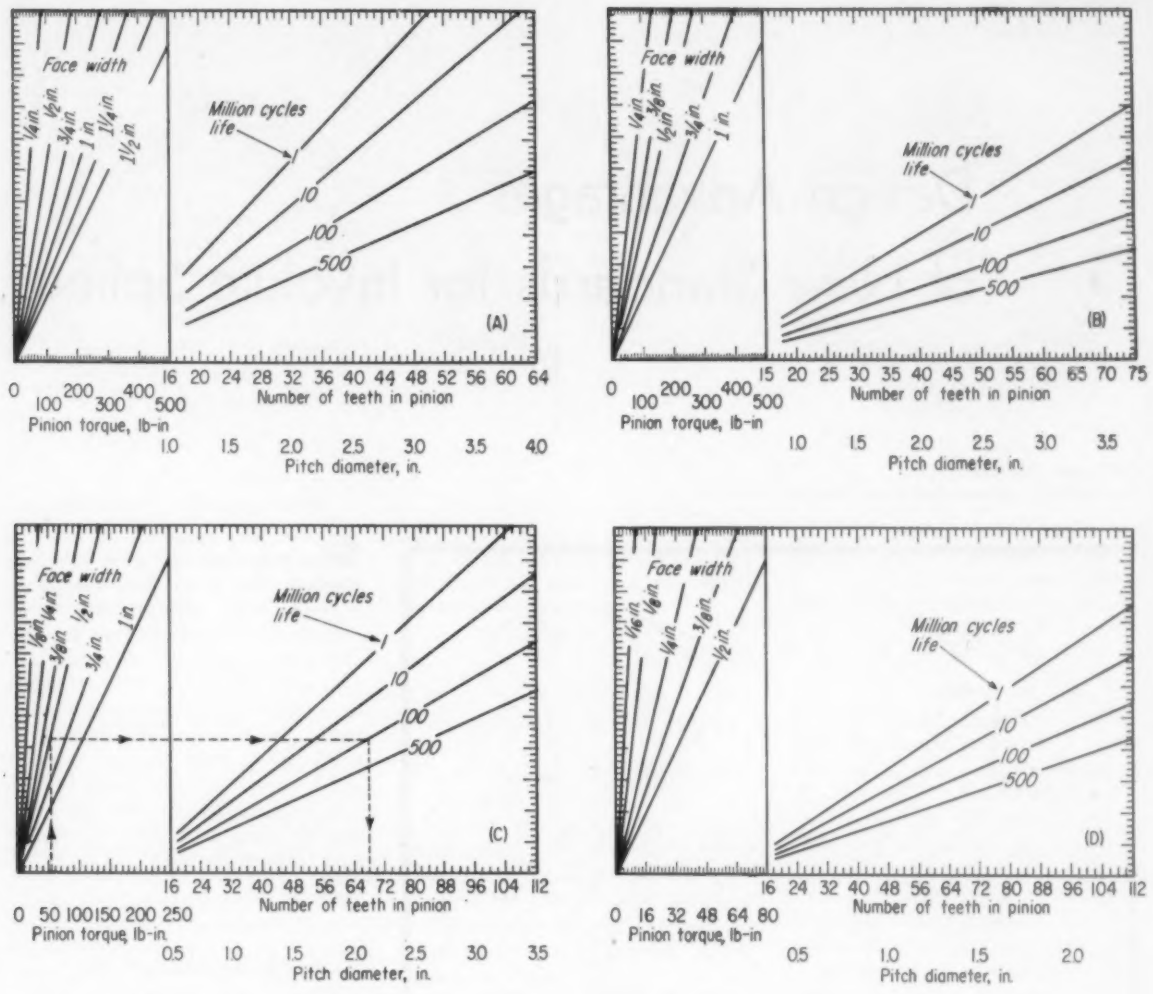


Fig. 6—Design charts for full depth molded Zytel gear teeth, 20° pressure angle, oil lubricated. (A) 16-pitch gears. (B) 20-pitch gears. (C) 32-pitch gears. (D) 48-pitch gears.

EXAMPLES USING DESIGN CHARTS

Example 1—A 32 pitch pinion having a ½ in. face width is to transmit a torque of 54 lb-in. at 1760 rpm. Teeth will be molded and lubricated. A life of 100 million revolutions is desired. What should be the pitch diameter of this pinion?

Design factor *K*, Table III, is 1.0 for molded and lubricated teeth with a pitch-line velocity below 4000 rpm; hence the design torque equals the actual torque of 54 lb-in. Solution is shown by dotted lines of Fig. 6 (C), the design chart for 32-pitch teeth. Line is started at 54 lb-in. on the torque scale, is extended upward to intersect the ½ in. face width, then drawn horizontally to the right to intersect the 100 million cycle line, and finally downward to find number of teeth, 68, and the pitch diameter, 2.125 in.

Example 2—What diameter is required for the pinion of example 1, if the teeth are formed by hobbing and no lubrication is used?

Design factor *K*, is 0.70 for 32-pitch cut teeth without lubrication. Design torque is 54/0.70 = 77.1 lb-in. Solution is now similar to example 1 except to start at 77.1 lb-in. on torque scale. Result is a pitch diameter of 3.0 inches with 96 teeth.

Example 3—What torque could the pinion of example 1 transmit if the teeth were not lubricated?

A design factor of 0.80 is indicated from Table III when the velocity is less than 4000 rpm. Actual torque which the pinion can transmit is (54)(0.80) equals 43.2 lb-in.

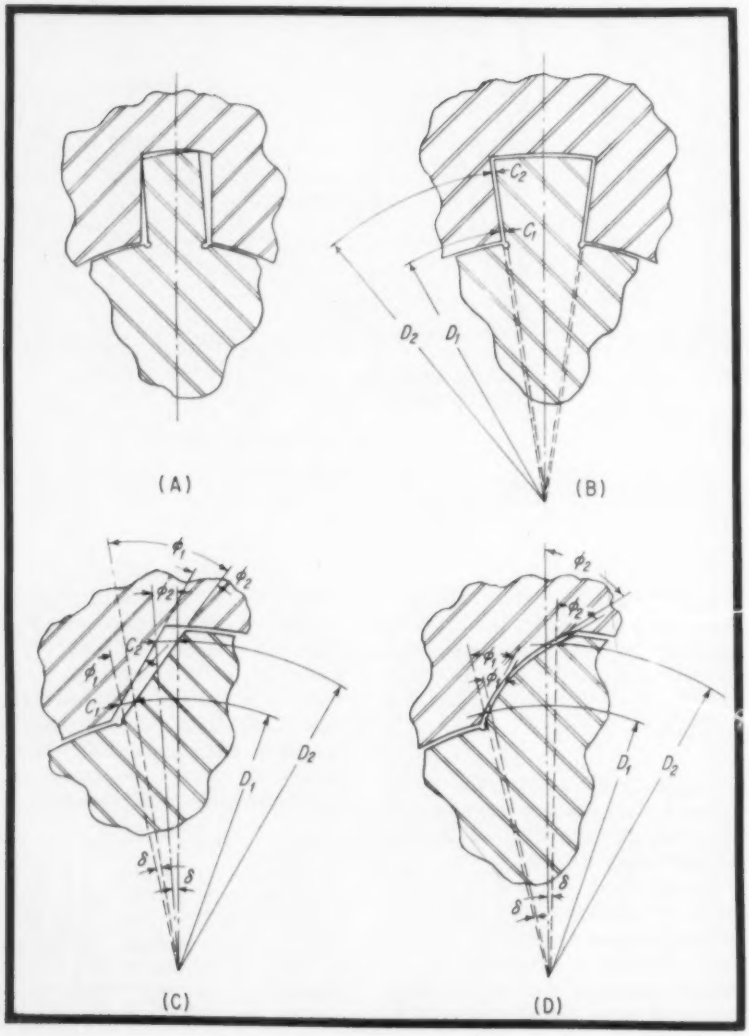
REFERENCE:

Design of Spur Gears of "Zytel" Nylon Resin by K. W. Hall, Professor, and H. H. Alvord, Associate Professor, University of Michigan, Ann Arbor, Michigan. Paper presented at the 1958 ASME Annual Meeting, New York. Paper No. 58-A-209.

From: SAE Paper

Design Advantages of New Standards for Involute Splines

LEON N. DE VOS,
Product Design Engineer Ford Motor Company



Standards give a sound basis for selection of a design that will satisfy assembly needs and yet be flexible enough to allow adjustments for specific performance and/or production conditions. The new SAE standards for involute splines minimizes troublesome areas of design: the problem of tooth contact, improves tooth strength and load-carrying ability; and the dimensional problem of matching tooth area to space area without interference between the parts.

Fig. 1—Why the Involute Profile . . .

A— . . . Straight sided spline has only line contact on the side of the tooth when clearance is needed between mating parts. Shaft rotation places the tooth tip under load before any other tooth point is contacted.

B— . . . Variation of straight sided spline permits full profile contact since clearances (C_1, C_2) are in proportion to diameters (D_1, D_2). However, spline shape is impractical and cross section at root of tooth is weakened by taper.

C— . . . Straight sided serrated spline overcomes impractical cross section and weak cross section at root. Pressure angles (ϕ_1 and ϕ_2) are the same for both profiles giving full contact area.

D— . . . Involute spline gives added advantages of easier manufacturing and inspection over straight sided serrated spline. Increased minor diameter (D_1) gives a wide base tooth with greater shaft and spline tooth strength.

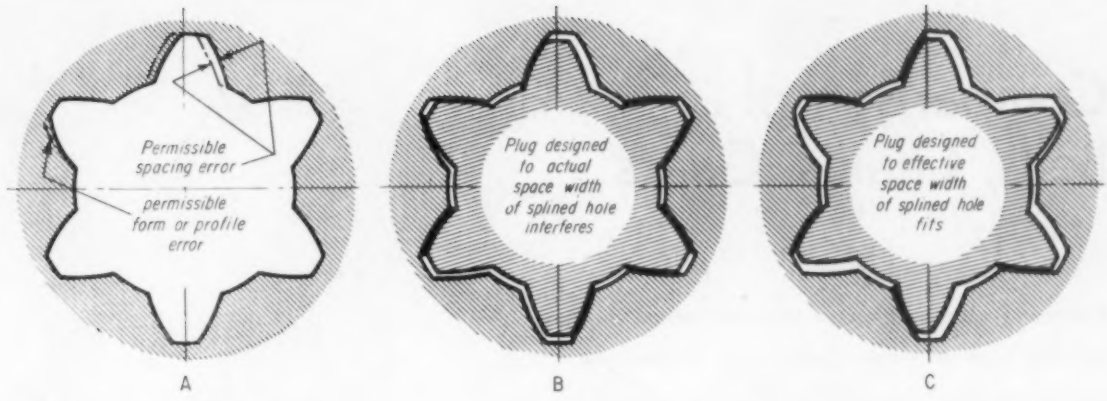

Permissible spacing error
permissible form or profile error
Plug designed to actual space width of splined hole interferes
Plug designed to effective space width of splined hole fits
A
B
C

Fig. 2–Dimensional Control of Spline . . .

A– . . . Internal spline with pitch and profile errors; out of roundness and lead errors not shown. Errors are within permissible design limits.

B– . . . Ideal spline contour, without errors, does not fit the internal spline even though each tooth has the same width as the corresponding mating space.

C– . . . to fit any position, ideal teeth must be reduced in thickness by amount of interference. Effective space width of spline is equal to this reduced width.

AREA OF CONTACT

Involute design gives the greatest amount of tooth profile contact regardless of the backlash in the splined connection. Backlash or clearance is usually necessary to assure assembly under a variety of conditions. Large contact area is made possible by equal pressure angles at the same reference diameter for both splines. Fig. 1 shows the basis of the involute design.

Standard is based upon a 30° pressure angle to give a wide base tooth for strength and still permit sliding along its length under normal torque loads. Pressure angle is also advantageous on fine pitch splines that are case hardened. Tooth configuration allows a soft core at the base of the tooth giving resistance to breakage.

A 45° pressure angle for involute serrations is used on splines of close fits which are not subject to sliding. These splines have greater contact pressures because of increased radial forces. They are generally used when manufacturing advantage can be gained.

TOOTH-TO-SPACE MATCHING

Standard incorporates a method of specification that assures the final assembly to be of a quality and fit range necessary to its proper function. This is accomplished through "effective" and "actual" dimensions. Fig. 2 and the explanation below shows how these dimensions work.

The effective space width of an internal spline, for example, minus the effective tooth thickness of the external spline is the effective clearance, and establishes the fit between the internal and the external spline mating surfaces.

The width of individual spaces, which is greater than the effective space width, is the actual space width of the internal spline. The actual tooth thickness of the external spline, always smaller than the effective tooth thickness, is the circular thickness on the pitch circle of single teeth.

The difference between effective and actual dimensions represents the accumulated effect of the spline errors and is termed the effective error, and the amount of permissible effective error is the error allowance between the mating parts.

The need for establishing effective and actual dimensions was created by the tooth-to-space matching error. Splines are designed to provide locations on a multitude of matching tooth surfaces. To dimensionally control 8, 12, 16, or more teeth and spaces has always been a major production problem, besides violating an elementary rule of machine design—multiple locating surfaces should be avoided wherever possible in design.

To illustrate this rule assume a slide on the bed of a machine tool. To horizontally locate the slide and to support a portion of the weight a V-groove is normally used. A raised pad carries the remaining weight. Two V-grooves create a problem of fitting caused by slight differences in the width, the spacing, and the parallelism of the grooves.

But spline design requires a great many grooves—or teeth—to act as locators. It must be recognized, however, that the fit between the mating splines is not sufficiently defined by just the space width of the internal spline and the tooth thickness of the external spline; the fit is also effected by errors in spacing, profile, out-of-roundness, and lead.

REFERENCE:
The Advantages of the New SAE Standard for Involute Splines from a Design Standpoint by Leon N. DeVos, Product Design Engineer, Transmission and Chassis Division, Ford Motor Company, Dearborn, Michigan. Presented at the 1959 SAE Annual Meeting, Detroit, Michigan. Paper No. 28R.

From: Design Engineering Conference paper

Comparison of Belts, Chains, Gears

Factors to be considered in the selection of the most suitable type of mechanical power transmission system are discussed and tabulated for convenient reference. Design factors are given.

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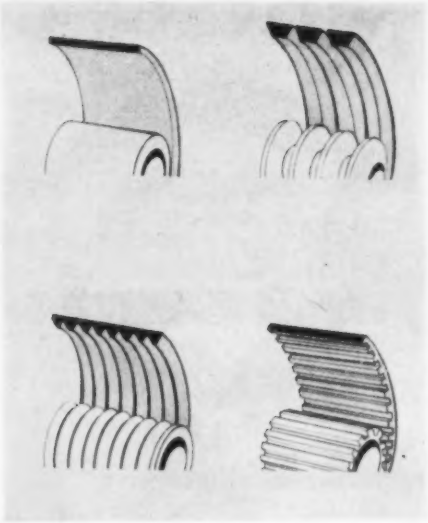


Belt Types . . .
. . . flat . . . V-belt, mulitple or single . . . ribbed . . . toothed. These vary in cost. Applications are dependent upon the general and special design factors selected for the transmission.

Whether a transmission be of conventional design or more radical in nature, three steps should be followed in reaching a final design: (1) determine the requirements of the proposed transmission; (2) make a preliminary selection of possible types; and (3) a detailed selection of the optimum transmission types.

DRIVE REQUIREMENTS

Normally, the power to be transmitted, the over-all speed ratio, rpm of one of the shafts, and the life requirement of the drive are known. However, other quantities may be equally important, for example, hospital machinery must be quiet, equipment for the textile industry must not soil the goods, and a drive for an experimental process machine may require speed adjustment.

Requirements such as these must be identified by study of the over-all drive application, and reduced to quantitative specifications. A failure here, can lead to invalidating an otherwise sound design

PRELIMINARY SELECTION

Once firm specifications are set up, they should be compared with the properties and capabilities of the various types of transmissions available. Table I compares the specific drive requirements and the properties and capabilities of the principal types of belt, chain, and gear transmissions.

General factors are those which are universally present in transmission design problems; special factors are those most often met in particular applications of the transmission design.

Ratio. Primary decision is whether the drive must be stepped in several reductions or can be designed as a single reduction. There is no inherent quality about any of the three transmission types which set up a ratio limit beyond which they will not function. However, limits do exist and analysis indicates there are three practical limiting factors; space, cost and efficiency.

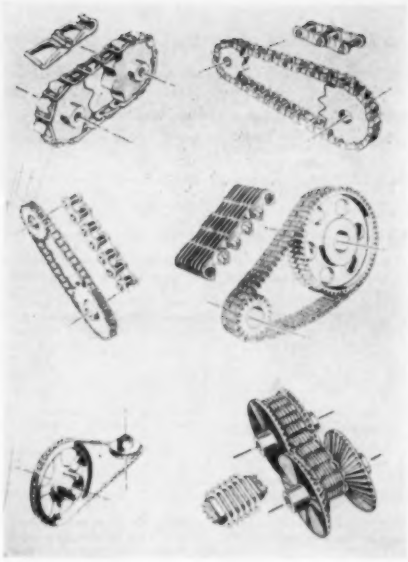
A large single-reduction drive set requires a large slow-speed element; the size of the high-speed element is set by the power transmitted. The area of the low-speed element in a single reduction drive increases by the square of the ratio. However, the area of the two low-speed elements in two approximately equal reverted reductions is directly proportional to overall ratio.

Even if space for a drive is ample, the ratio of the drive may still be limited by the cost of the slow speed element. As the size of these elements increases, their cost rises rapidly whether they be gears, sprockets or pulleys. At some ratio it will be found less expensive to pay for the extra parts necessary to step the drive than to construct one large part.

Speed. In a transmission of a given power level, the tangential speed and load are inversely related. Varying the diameter of the elements will give an optimum arrangement which is the least costly drive using the highest speed possible.

Belts are capable of satisfactory operation at high speed. Flat belts have been operated at speeds of 24,000 fpm. Limiting factor is tension developed in the belt by centrifugal forces.

Generally, chains cannot be run as fast, and are limited by the effect of impact loading. This loading occurs as the chain runs onto the sprocket forming a series of chords around the sprocket pitch line.



Chain Types . . .
. . . detachable . . . offset-sidebar . . . roller . . . silent . . . bead . . . variable speed. Chains, of course, vary in cost and application

Gear types classified by shaft relationshops . . .
. . . parallel . . . intersecting . . . skewed

Speed limitation of gear drives is a function of tooth profile accuracy, spacing accuracy and the amount of the tooth distortion under load. These errors cause impact as the tooth comes into mesh and the effect increases with pitch line speed. These effects have been minimized to permit gear speeds to 30,000 fpm by: (1) development of accurate machining methods; (2) modification of the theoretical tooth profile; (3) use of fine pitch gearing; and (4) use of helical teeth.

Load. Principal problem is the establishment of the design load to be used in proportioning the drive parts. It is usually computed by multiplying the nominal load by a service factor. The service factor should account for variations from constant load, nature of the prime mover, and the peculiarities of the duty cycle.

The effect of load as a selection parameter is expressed in Table I as a number which represents the width of a drive relative to a spur gear width of unity for a drive of the same geometry, power and speed. Base gear is assumed to be of steel at 300 Brinell hardness. Service factor is assumed at 1.00. The values quoted are averages to indicate a relationship, and are not offered as design data.

Transient conditions are often overlooked, and can be the limiting factor in a design. For example, a high inertia load in a duty cycle requiring frequent starts, may demand starting torques so much more severe than the nominal steady state torque that the transient starting conditions control the design. Belts may slip badly and be prematurely destroyed; chains and gears may generate undesirable noise and be subject to impact damage.

Life. Design factors which determine the life of belts are; speed, sheave diameter, load, and length. These factors determine the magnitude of the peak stresses suffered by each increment of belt length as it passes off the driven pulley and, again, on to the driver pulley, and the number of these peaks per minute. Knowledge of the magnitude and frequency of stress peaks permits calculations of the expected life using experimental stress-life data.

An important belt-life factor which should not be overlooked is the temperature at which the belt operates. This temperature is a function of internal friction in flexing, external friction in sheave contact and ambient conditions. If the operating temperature can be limited by design, control of ambient conditions, or duty cycle, belt life can be extended.

Chain life is limited by either of two types of failure: (1) excessive elongation; or (2) chain breakage. The first is caused by wear which results in the chain topping the sprocket teeth; the second is caused by fatigue crack propagation in the link sides.

Most chain selection procedures are based on fatigue-free operating life of 15,000 hours in which a 3% wear elongation is suffered. The design factors which affect wear rate of chain have not been fully identified, hence the procedure for designing for some other wear life is empirical, and should be based on test results.

Gear life is expressed in terms of total stress cycles through which the teeth pass. Much experimental data has been compiled by various segments of industry. The automobile industry, for example, has developed largely empirical procedures which permit reliable design of a low-speed range pinion for many applications where such gears are desirable.

Table I–Properties and Capabilities of Belts, Chain, and Gears

		BELTS					
		Leather (Flat)	Rubber Fabric (Flat)	Plastic Core (Flat)	Standard (Vee)	Steel Cable (Vee)	Toothed
General Design Factors	Ratio	16:1	16:1	20:1	12:1	12:1	11:1
	Speed (Feet per min.)	6000	13,000	24,000	5000	8000	15,000
	Load (Equivalent Width)	5.9	.....	.....	6.7	.....	3.0
	Life	Depends on speed, pulley diameters, tension and total belt length. Published data and selection procedure available for vee belts. Generally less than 15,000 hours.					
	Center Distance	Independently variable — no interrelationship between pulley diameters and distance. Wear and retensioning takeup adjustment must be provided either by adjustable center distance or extra mechanism.					
Special Design Factors	Shaft Relationship	Connected shafts can be skewed up to 180° but belt capacity and life will be reduced accordingly.					
	Ratio Accuracy	Subject to slip and creep. Normal amounts to 1 to 5% but amounts vary widely with tension ratio and contact pressure.					Delivers a fixed ratio
	Vibration and Noise	Generally free of vibration. Subject to noise due to belt slap.			Quiet and free of vibration.		Vibration frequencies generated by tooth action
	Efficiency	Up to 98% at rated steady load. Efficiency will reduce with varying load.					
	Lubrication	No lubrication required.					
	Environment	Practically any environmental condition can be met by proper selection of material. Temperature range −60 to +225 F.					
	Maintenance	Retensioning	Retensioning	Periodic application of special belt conditioner	Retensioning	Retensioning	.....

The current proposed gear rating formula of the AGMA contains seven separate modifying factors each of which accounts for a known operating or design variable affecting the rating of a pair of gears. One factor is a measure of the expected life of the gear set in number of cycles.

Center distance. A short center distance demands small pitch diameters and strongly suggests the use of gears as these can have the greatest load capacity per inch of pitch diameter of the three drives.

Large center distances generally compel consideration of belts or chains as pitch diameter and center distance for these drives are not interrelated.

Shaft relationship. The relationship is the geometric disposition of the shafts —parallel, intersecting, or skewed. If one of these relationships is imposed then restrictions on drive selection may exist.

Belts are fairly flexible. Flat belts can be used to connect shafts skewed at any angle, and can operate with intersecting shafts if guide pulleys are used. V-belts can be successfully operated in quarter-turn arrangements. These measures twist the belt and force a reduction in belt capacity because of unequal tension across the belt width.

Chain is limited in this respect. Only bead chain is available to connect nonparallel shafts. These can drive shafts which are skewed up to 90° or intersect at angles up to 40°.

Gearing can be designed to connect shafts of any angular relationship. The accuracy of shaft alignment is sometimes a factor in drive selection. Gear shaft alignment should be held to an accuracy of about 0.0005 per inch of gear face to give satisfactory tooth contact. Shaft alignment for belt and chain drives need not be as accurate.

Ratio accuracy. Friction belt drives are subject to speed distortion caused by slip and creep and thus have little application in devices requiring a high degree of ratio accuracy–degree to which the drive transmits undistorted motion from the input to the output shaft. Toothed belts, however, being positively engaged with their pulleys, are widely used where exact ratio is a requirement.

Chain drives produce a specific average ratio because of positive engagement, but the instantaneous speed ratio constantly varies because of chordal action. Where ratio accuracy is required, the amount of permissible distortion must be evaluated, and a chain and wheel size selected to meet the requirements.

Gear tooth design results in theoretically perfect action so that the instantaneous ratio is constant. As a result, most trains requiring high ratio accuracy use gearing.

Vibration and noise. Constant cross section friction belts usually run quietly. Inherent vibration and some noise may result if cogged or toothed belts are used at high speed. Changes

CHAINS						GEARS									
						Parallel Shaft			Intersecting Shaft			Skew Shaft			
Bead	Detachable	Pintle	Offset-Side-Bar	Inverted Tooth (Silent)	Roller	Straight Spur	Helical	High-Speed Herringbone	Straight Bevel	Spiral Bevel	Face Gear	Worm	Tapered Worm	Hypoid	Crossed Helical
....	2½	2½	4:1	12:1	8	6	10	15	4	4	10:1	75:1	200:1	6:1	....
200	350	450	1000	6500	5000	4000	10,000	30,000	4000	8000	.....	6000	6000	8000	6000
....	...	...	....	1.9	1.6	1.0	.....	.....	....	....	.....	....	....	.....	....
Catalogue selections based on 15,000 hours.						Substantial quantity of life information is available. Consult latest AGMA publications. Can be greater than 15,000 hours.									
Independently variable—no interrelationship between sprocket diameters and center distance for a given ratio. Wear takeup required.						$CD = \frac{D+d}{2} = \frac{d(R+1)}{2}$ CD = center distance d = pinion pitch diameter D = gear pitch diameter R = Ratio			No center distance since shafts intersect.			Center distance is not directly related to ratio or pitch diameter.			
Connected shafts can be skewed up to 90°	Connected shafts must be nominally parallel.					.....			Any included angle can be used.		Normally 90° angles are used.	90° skew angle		Any skew angle.	
Delivers a fixed ratio. Instantaneous velocity ratio varies cyclically with chordal action.						All gearing delivers exact ratio. Instantaneous velocity is theoretically uniform—any variation is due to profile and spacing inaccuracies.									
Noise and vibration are inherent due to chordal action. Large diameter sprockets, flywheels, and special silent chain designs can minimize but do not eliminate chordal action effects.						Frequency generation is inherent due to tooth contact. Practically noiseless drives can be achieved by special design and fabrication measures.									
96–99%						98–99%			95–98%		.....	20–98% Varies with size and ratio		95–98%	Wide variation depending on sliding
Capable of dry operation for short-life applications or low load. Best life is obtained with splash or drip lubrication.						Lubrication required to achieve high efficiency. Plastic and impregnated materials are available for low-load dry applications.									
Can be operated in abrasive atmosphere with somewhat reduced life.	Cannot be operated open in abrasive atmosphere. Special materials are available for various types of corrosive atmospheres. Temperature range: −60 to 600F					Cannot be operated open in abrasive atmospheres. Fully enclosed gear sets fairly independent of nature of atmosphere (providing seals are satisfactory). Ambient temperature range −60° to +300 F.									
Lubrication, retensioning and wear takeup.						Lubrication									

in belt configurations or in belt tension will usually solve the problem.

A chain drive will produce vibration and noise due to the chordal action of the links. The effects can be minimized by selection of chain specially designed to run smoothly, but vibration is inherent and always present in any design.

Gear drives produce noise and vibration in proportion to the amount of separation occurring as the tooth passes through mesh. Principal means of controlling noise are: (1) use of fine pitch helical teeth of modified profile; and (2) use of damping devices in gear structures, shafting, and housing that minimize noise.

Efficiency. This design factor determines the amount of input power required to furnish required output and the amount of cooling needed. Belts, chains, and gears can all be designed to operate at 95% or better for one reduction except for certain high-ratio arrangements. If the load cycle varies widely from the design load than at low loads the efficiency of the belt drive will be less than the efficiency of other types.

Lubrication. Belts require no lubrication and are particularly applicable for use where lubrication is not possible. Certain chains—such as nylon—are self-lubricating.

Progress is being made to eliminate gear lubrication requirements, mostly through the development of impregnated materials and plastics. Nylon gearing of low load capacity falls in this category.

DETAILED SELECTION

Final selection is based on the known requirements of the drive which are supplemented by assumptions necessary to specify completely all of the general design parameters. The necessary cross section of the load-carrying element can then be calculated for the particular design.

For belts and chains, the data is available in catalogs which give the commercially available sizes of sprockets and pulleys, and the load carrying capacity of the various cross sections.

For gearing, the selection of teeth will lead to problems involving geometry, stress analysis, and material specification. The AGMA has developed a standard rating method which is conveniently arranged to select the proper gear.

But, the final selection is made on the basis of cost. Careful estimates can be made only when all components—bearings, lubrication cases, idlers, automatic tensioning devices, machined housings—construction and erection are considered.

REFERENCE:
The Design and Application of Belts, Chains, and Gears by E. S. Cheaney, C. L. Paullus, W. C. Raridan, Principal Engineers, Battelle Memorial Institute, Columbus, Ohio. Presented at the ASME Design Engineering Conference, Philadelphia, Pa., May 1959. Paper No. 59-MD-6.

Planetary Gear Train Design

From: SAE Lecture

Method for calculating planetary gear ratios which can be applied to determine the usefulness of any planetary configurations. Criteria to help evaluate the potential of a planetary gear train schematic. Information on pinion spacing, gear noise, bearing design.

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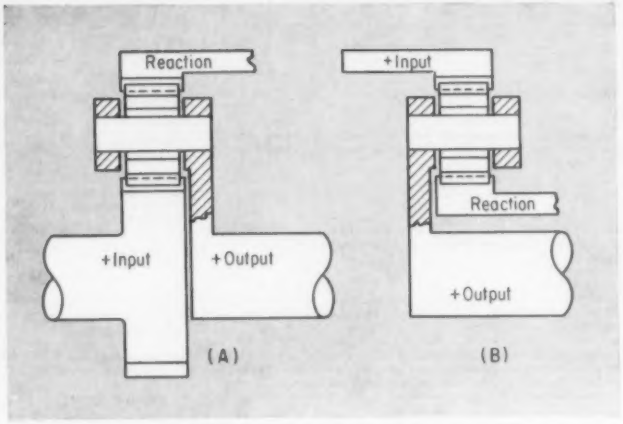


Fig. 1—Single, simple planetary gear system. (A) Where the sun gear is driving and the ring gear is the reaction element, reduction ratios of 2.8/1 or greater are obtainable. (B) When the ring gear is driving and the sun gear is the reaction member, the trouble point of small pinions show up when reduction ratio of 1.55/1 or more are attempted. Between 1.55/1 and 2.8/1 compound planetaries are needed.

Compact design, more efficient gearing and bearing design, easier to make quiet, and more suitable for designs of uninterrupted power shifting are the major advantages of planetary gear train over the countershaft gear train designed for the same function. To take advantage of these qualities, however, a choice from a wide variety of compounding systems must be made and some special gear and bearing problems solved.

SELECTING THE GEAR REDUCTION

A single simple planetary gear system, Fig. 1, will supply reduction gear ratios between 1.35/1 and 1.55/1 when the ring gear is driving and the sun gear is the reaction member. A 2/1 reduction ratio is impossible with a simple planetary gear system because it would require zero pitch diameter pinions.

Hence, the compound planetary gear system. The impossible 2/1 reduction ratio is achieved in several ways, Fig. 2; by dividing the work between the planetary sets, or using a regenerative system.

Both designs are useful. The first is a good way of obtaining two different reduction ratios through use of either the first ring gear or the first carrier as the reaction member, thus getting optimum efficiency. The second design obains a single reduction ratio and approximately

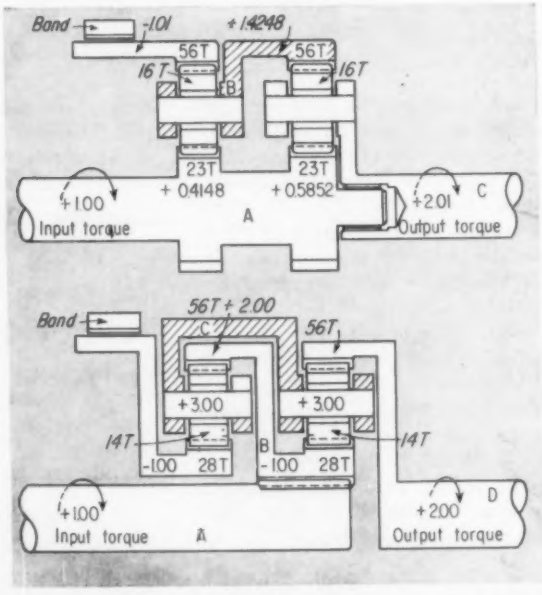


Fig. 2—Compound gear train designs. (A) Train uses one planetary set to reduce the full-speed gear action of the second set, thus also reducing the final drive ratio of the second set. (B) Left-side ring gear input planetary drives the right-side planet carrier at a reduction ratio. Planet pinions of the right-side carrier split the carrier torque between the output ring gear and the original input shaft to increase the input torque artificially.

equal reverse ratio by using either the first sun gear or the carrier combination as a reaction member, resulting in reasonable efficiency.

When nearly 2/1 ratios are sought, the Ravigneaux compound planetary design, Fig. 3, is a solution and has the structural advantage of a single carrier. Since the same tooth load prevails throughout the train, the reaction gear tooth load equals the driving gear tooth load and the reaction torque is directly proportional to the number of teeth in the reaction gear and input gear.

Where less than 2/1 reduction ratio is involved the reaction gear is smaller than the input gear; where more than a 2/1 ratio is required the opposite is true. Design is widely used as it is one of the better ways of keeping pitch line velocities down, thus reducing noise.

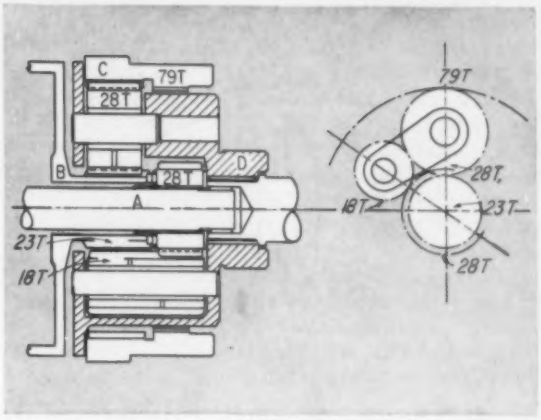


Fig. 3—Ravigneaux compound planetary gears. There are two sun gears, three long pinions, three short pinions, and a ring gear which is used for reverse reaction. The 28-tooth sun gear is the input, the 23-tooth sun is the forward reduction reaction gear, the 79-tooth planet ring gear is reverse reaction gear, and the planet carrier is the output member. Both forward and reverse reduction ratios are 1.82/1.

SYSTEM ANALYSIS

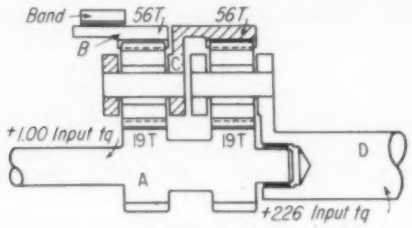
As the arrangements of compound systems become more complicated a rapid method of determining, (1) the reduction ratios available from a given design, and (2) whether the parts will go together, is needed. The following steps, shown in Fig. 4, will solve the first problem.

1. Hold any member of a gear train and turn another member one turn. Record the speed for each rotating member of the gear train when the speed of the held member is zero. The resulting values disclose the speeds of all the members of a gear train.

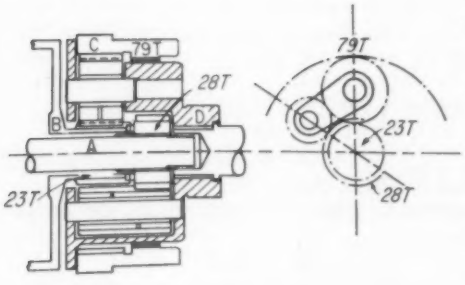
2. Choose any of the rotating members for the next possible stationary member and add an equal quantity of opposite sign to its speed value. This makes its speed value zero. Then, add this same quantity to all the other speed values. The original zero value member has a speed and all values are changed.

3. Repeat this procedure until every member has been equated to zero, while the other members have changed their speeds to corresponding new values.

Fig. 4—Analysis of double planetary gear and a Ravigneaux gear train. Reciprocals would give twelve overdrive ratios.



Double planetary



Ravigneaux

	A	B	C	D	Step 4 Reduction Ratios Forward	Reverse
Step 1	+1.00	-.0393=19/56	0	+.02533=19/75	A/D=3947 to1	A/B=2.947 to 1
	-.02533	-.02533	-.02533	-.02533		B/D=1.34 to 1
Step 2	+.07467	-.05920	-.02533	0	B/C=2.337 to 1	A/B=1.261 to 1
	+.05920	+.05920	+.05920	+.05920		A/C=2.947 to 1
Step 3	+1.3387	0	+.03387	+.05920	A/C=.3947 to 1	
	-1.3387	-1.3387	-1.3387	-1.3387	A/D=.226 to 1 D/C=1.747 to 1	
Step 3a	0	-1.3387	-1.00	-.0767	B/C=1.3387 to 1 C/D=1.3387 to 1 B/D=.1793 to 1	

	A	B	C	D	Step 4 Reduction Ratios Forward	Reverse
Step 1	+1.00	-.12174=28/23	+0.3544=28/79	0	A/C=.2821 to1	B/C=.3435 to 1
	-.03544	-.03544	-.03544	-.03544		B/A=1.2174 to 1
Step 2	+.06456	-.15718	0	-.03544	B/D=4.435 to 1	B/A=.2434 to 1
	+1.5718	+1.5718	+1.5718	+1.5718		A/D=1.821 to 1
Step 3	+2.2174	0	+1.5718	+1.2174	A/C=1.410 to 1	
	-2.2174	-2.2174	-2.2174	-2.2174	A/D=1.821 to 1 C/D=1.291 to 1	
Step 3a	0	-2.2174	-.06456	-1.00	B/C=.3435 to 1 B/D=2.2174 to1 D/C=1.549 to 1	

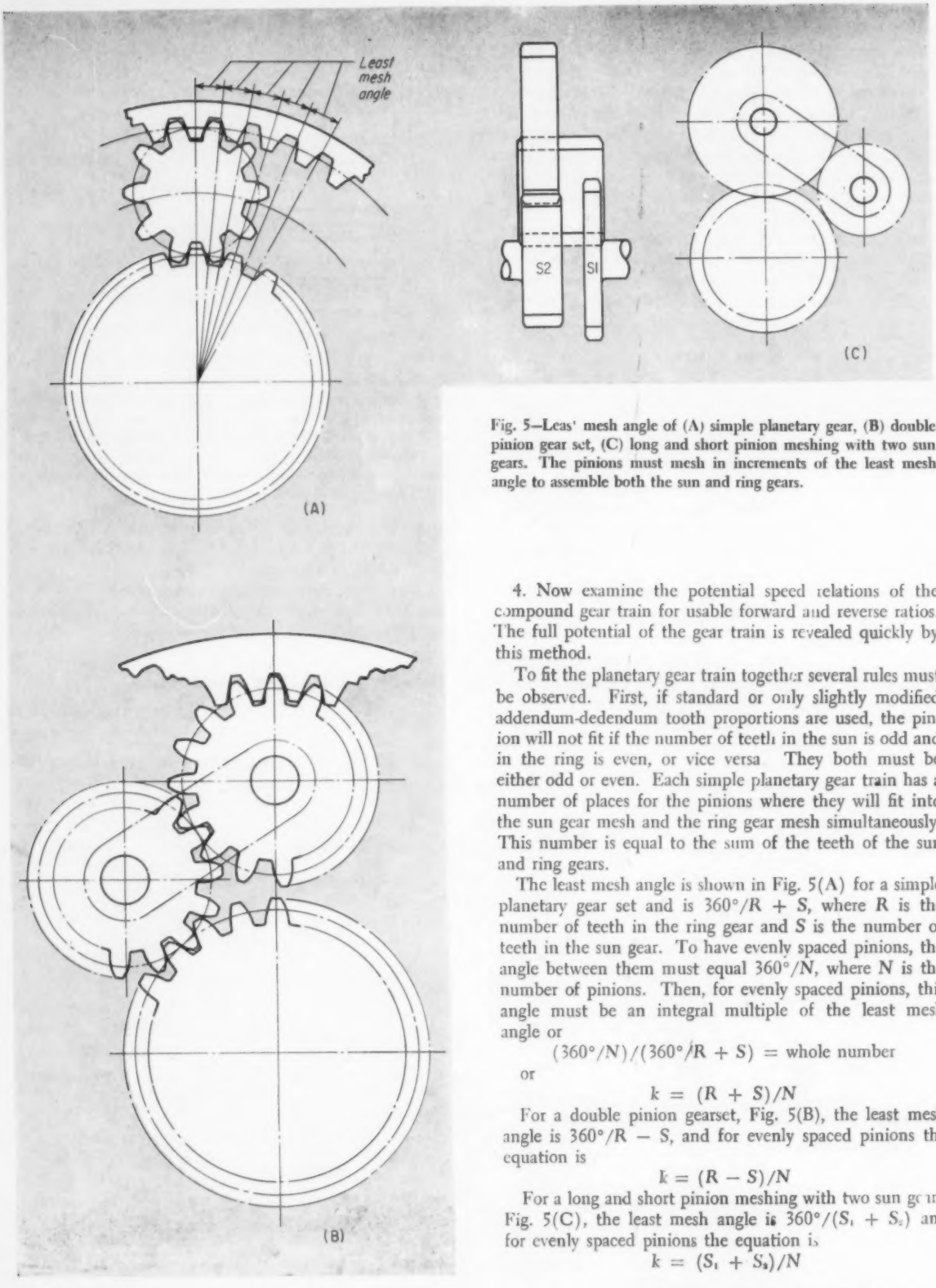


Fig. 5—Leas' mesh angle of (A) simple planetary gear, (B) double pinion gear set, (C) long and short pinion meshing with two sun gears. The pinions must mesh in increments of the least mesh angle to assemble both the sun and ring gears.

4. Now examine the potential speed relations of the compound gear train for usable forward and reverse ratios. The full potential of the gear train is revealed quickly by this method.

To fit the planetary gear train together several rules must be observed. First, if standard or only slightly modified addendum-dedendum tooth proportions are used, the pinion will not fit if the number of teeth in the sun is odd and in the ring is even, or vice versa. They both must be either odd or even. Each simple planetary gear train has a number of places for the pinions where they will fit into the sun gear mesh and the ring gear mesh simultaneously. This number is equal to the sum of the teeth of the sun and ring gears.

The least mesh angle is shown in Fig. 5(A) for a simple planetary gear set and is $360°/R + S$, where R is the number of teeth in the ring gear and S is the number of teeth in the sun gear. To have evenly spaced pinions, the angle between them must equal $360°/N$, where N is the number of pinions. Then, for evenly spaced pinions, this angle must be an integral multiple of the least mesh angle or

$$(360°/N)/(360°/R + S) = \text{whole number}$$

or

$$k = (R + S)/N$$

For a double pinion gearset, Fig. 5(B), the least mesh angle is $360°/R - S$, and for evenly spaced pinions the equation is

$$k = (R - S)/N$$

For a long and short pinion meshing with two sun gears, Fig. 5(C), the least mesh angle is $360°/(S_1 + S_2)$ and for evenly spaced pinions the equation is

$$k = (S_1 + S_2)/N$$

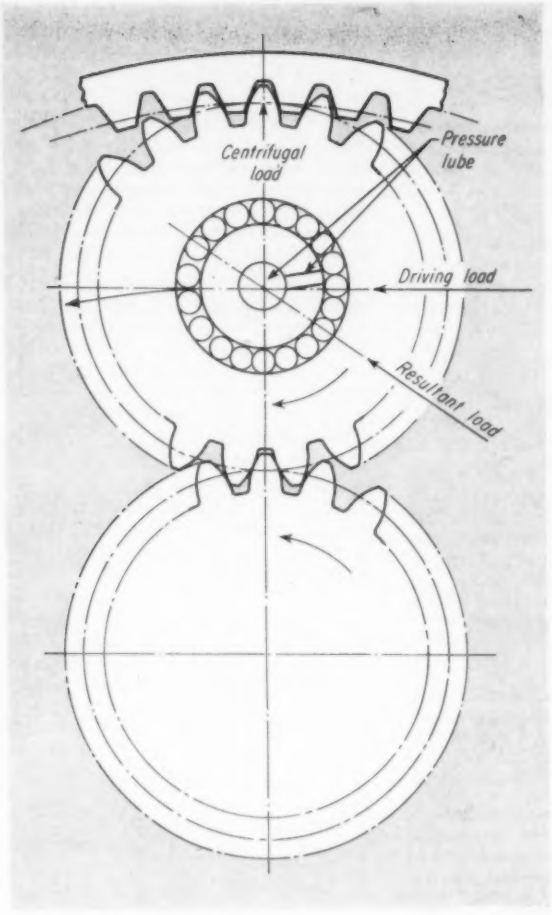


Fig. 6—Centrifugal load on pinion gear. Needles lose rotational speed because of rubbing friction when not under load. When forced to the load-carrying part of bearing, high rotational acceleration causes further wear. Problem is usually found in heavy-duty high-speed equipment.

An example of this technique is a Ravigneaux gear set, Fig. 3, with the following number of teeth. Ring gear (R) = 79, front sun gear (S_1) = 23, rear sun gear (S_2) = 28.

The Front gears form a simple planetary set and

$$k = (R + S_1)/N = (79 + 23)/3 = 37$$

The Rear sun gear, the two pinions, and the ring gear are a double pinion set and

$$k = (R - S_2)/N = (79 - 28)/3 = 17$$

The two sun gears and the pinions are another gear set to consider and

$$k = (S_1 + S_2)/N = (23 + 28)/3 = 17$$

All these combinations result in whole numbers which means the transmission will assemble and the pinions are equally spaced. Without such a check, it is difficult to determine if an interference exists.

GEAR NOISE

Gear noise is proportional to the square of the meshing pitch line velocity. Everything else being equal, the greatest single help comes from reduced pitch line velocities. This is the advantage of planetary gears. They offer many choices of designing a gear train for most needs that still give low pitch line velocities and are easier to make quiet in operation.

Helix gear planetary designs which depend on the helix overlap for tooth engagement are often noisier when carrying light loads only. This is caused by slight misalignment of opinions, which tends to cause gear edge loading only, thus losing all help from the helical overlap. Load application on the pinion teeth at both the sun and ring gear contacts will deflect the structure sufficiently to establish contact across the face of the gear, thus bringing into full advantage the helical overlap.

BEARING DESIGN

The pinion gear presents a bearing problem in a simple planetary system as the sun and ring gears do not carry a driving load. The pinion gears usually use needle bearings to transmit loads to the pinion carrier. These needles must resist destructive end-thrust and centrifugal forces.

The relatively flexible long bearing needle tries to roll on a deflected-at-the-middle shaft and also on the inner surface of a rigid pinion bore. This does not give true rolling action. Also, the high helix angle thrust loads, especially in the larger pinions, impose a cocking couple on the bearing. This shifts the load to a spiral pattern on the sides of the deflected shaft. The resultant spiral pattern can produce high end thrust on the needles. Hardened steel thrust washers on the pinion shafts between the pinion and the carrier are generally adequate to resist this thrust. Needle-bearing thrust-washers are often used to increase the transmission gear train thrust capacity.

Helical gears in planetaries produce equal and opposite thrust loads on the sun gear and the ring gear. In the case of a small diameter driving sun gear, this thrust load can produce a real problem. To cope with this problem, end thrust washers are used which have small needle bearings mounted in the washer. The short needle bearings are caged radially to absorb the end thrust loads of the driving and driven gears.

High centrifugal forces in planet carriers can cause severe rubbing action between the needles in the pinion bearing. Fig. 6 shows that this force makes the needles bunch together during the unloaded portion of their trip around the races. The resultant rubbing action causes each needle to lose its rpm. When the needle enters the actual working part of the path, it must accelerate instantaneously to the full rotational speed of the bearing. This causes slippage, wear, and heat. The solution is the use of caged needles and extreme lubrication.

REFERENCE:

The Design of Planetary Gear Trains by Oliver K. Kelley, Chief Engineer, Buick Motor Division, General Motors Corporation. Presented at the SAE Annual Meeting, January 1959. Paper is the 5th L. Ray Buckendale Lecture.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(E-1) **Gears, Sprockets and Gear Rack**—Brochure, 4 pp. Description of facilities and capacities. E B Sewall Mfg Co, 705 Raymond Ave, St Paul, Minn.

(E-2) **Speed Reducers**—Catalog, 175 pp. Outline drawings of stock, special, precision and commercial gears. Engineering section is included. Grant Gear Works, Inc, 158 W Second St, South Boston, Mass.

(E-3) **Tooth Clutches** — Bulletin, 4 pp. Covers line of eight different electromagnetically operated positive type tooth clutches. Specifies physical dimenisons, technical rating data and accessories. Full scale outlines of clutches are included for tracing. McCauley Industrial Corp, Elmag Div, 1840 Howell Ave, Dayton 17, Ohio.

(E-4) **Disc Clutches**—Brochure, 12 pp. Covers the complete line of electromagnetic multiple disc clutches and brakes for use in machine tool industrial equipment. Specifies physical dimensions, torque ratings, wattage consumption, maximum rpm and inertia of clutch and brake models. Typical examples for clutch and brake installations are shown. McCauley Industrial Corp, Elmag Div, 1840 Howell Ave, Dayton 17, Ohio.

(E-5) **Belting, Industrial Hose and Packing**—Brochure, 6 pp. Information of construction and specifications. Boston Woven Hose & Rubber Co, 29 Hampshire St, Cambridge, Mass.

(E-6) **Clutch-brake Drive**—Brochure, 6 pp. Use of packaged electromagnetic drive as building block in power train assemblies. Engineering data for standard drives. Illustrates various basic assemblies and engineering data sheets available. Cycledynamics Inc, 19025 W Davison Ave, Detroit 23, Mich.

(E-7) **Power Transmission Equipment**—Catalog, 19 pp. Stock sizes of v-belt drives, roller chain drives, bearing units, couplings, paper pulleys, set collars, and split taper bushings. Browning Mfg Co, Maysville, Ky.

(E-8) **Transmission Products**—Catalog, 136 pp. Gives list of stock products as to size, type, how to order and price list. Morse Chain Co, S Aurora St, Ithaca, NY.

(E-9) **Precision Gears and Differentials**—Catalog, 88 pp. Listing and pricing of precision gears, differentials and components. Diameters: all fine pitch 48 thru 120—20 thru 300 teeth. Dynamic Gear Co, Inc, 20 Merrick Rd, Amityville, NY.

(E-10) **Reversing Transmission**—Bulletin, 4 pp. Description, features, operation, and power rating curves. Snow-Nabstedt Gear Corp, 251 Welton St, Hamden, Conn.

(E-11) **Magnetic Clutches**—Catalog, 4 pp. Contains descriptions of four models of magnetic clutches ranging from ½ to 1⅝ in. in dia. Magnetec Corp, 11785 W Olympic, Los Angeles 64, Calif.

(E-12) **Transmission Stock Products**—Catalog, 96 pp. Gives complete engineering dimenisons and selection data for the products generally carried in stock by distributors: concentric shaft helical gear reducers, worm-gear reducers, flexible gear type couplings, shelf mounted motor drives, and gearmotor integral motor drives. Foote Bros Gear and Machine Corp, 4545 S Western Blvd, Chicago 9, Ill.

(E-13) **Transmission Equipment**—Bulletin, 4 pp. Engineering information on electromagnetic clutches, brakes, and clutch-brake combinations. Stearns Electric Corp, 120 N Broadway, Milwaukee, Wis.

(E-14) **Automatic Clutches**—Catalog, 8 pp. Describes construction and application. Gives engineering information and sizes of standard and specially engineered clutches. Mercury Clutch Div, Automatic Steel Products, Inc, 1201 Camden Ave, SW, Canton, Ohio.

(E-15) **Couplings**—Brochure, 4 pp. Details construction and application of gear, flexible and cut-out couplings. John Waldron Corp, River Road, New Brunswick, NJ.

(E-16) **Flexible Shaft Assemblies**—Catalog, 11 pp. Describes construction, types, selection and application; gives engineering data. Also, information on flexible housings, end fittings and typical applications. Flexible Shaft Div, Robertshaw-Fulton Controls Co, 110 Summit Ave, Chatham, NJ.

(E-17) **Magnetic Clutches**—Catalog, 8 pp. Explains construction, application and specifications for instrument clutches. Crown tooth and friction models, with and without brakes. Also, standard clutch coupling and brake combinations. Reeves Instrument Corp, Garden City, NY.

(E-18) **Worm Gearing**—Bulletin, 16 pp. Standard and custom-designed worm gear speed reducers and components for built-in drives. Fractional to over 450 hp, 3.000 to 21.837 in. center distances. The Cleveland Worm & Gear Co, 300 E 80th St, Cleveland 4, Ohio.

(E-19) **Electric Clutches and Brakes**—Catalog, 5 pp. For use in instruments, business and packaging machines and other types of industrial machinery where automatic control is important. Simplatrol Products Corp, 24 Salisbury St, Worcester, Mass.

(E-20) **Magnetic Disc Brakes**—Catalog, 8 pp. Application and description of operation, enclosures, torque range, mounting, dimension and ordering information. Dings Brakes, Inc, 4740 W Electric Ave, Milwaukee 46, Wis.

(E-21) **Transmission Components**—Catalog, 80 pp. Complete description as to hp and dimensions with selection tables plus engineering formulas covering gears, reducers, couplings and others. Each group color coded by major product line. Charles Bond Co, 617 Arch St, Philadelphia, Pa.

(E-22) **Speed Reducers**—Bulletin, 52 pp. Describes and illustrates variety of units. Included are specifications, hp rating tables, overhung load capacities and weights, and selection procedure. Farrel-Birmingham Co, Inc, Ansonia, Conn.

(E-23) **Automatic Clutches and Transmissions**—Bulletin, 4 pp. Automatic power transmisison devices for lower hp range motors and engines; specifications, selection charts, custom designing service data form. Salsbury Corp, 1159 E Florence Ave, Los Angeles 1, Calif.

(E-24) **Selective-speed Transmission**—Catalog, 32 pp. Hp and torque ratings, lubrication data, transmission ratios, bases and motor plates, ordering information. Turner Uni-Drive Co, 3416 Terrace, Kansas City 11, Mo.

(E-25) **Shaft-mounted Drives**—Catalog, 20 pp. Describes advantages gained in using this type drive as compared to base mounted type. Gives engineering dimensions, selection information, suggested applications, and ordering information. Foote Bros Gear and Machine Corp, 4545 S Western Blvd, Chicago 9, Ill.

(E-26) **Clutches**—Catalog, 76 pp. Automatic freewheeling clutches for single shaft drives; clutch-couplings for connecting shaft ends; backstops for conveyor or elevator headshafts; units for high speed, outdoor, continuous operation. Marland One-Way Clutch Co, PO Box 308, Elm & Washington Aves, LaGrange, Ill.

(E-27) **Industrial Clutches**—Catalog, 39 pp. Covers single revolution, over-running, slip and centrifugal clutches, and clutch couplings, plus packaged intermittent drive unit. The Hilliard Corp, 100 W Fourth St, Elmira, NY.

(E-28) **Differential-type Speed Reducer**—Brochure, 4 pp. Description of units and applications. Hart Reduction Pulley Co, 1116 Adams St, Waukesha, Wis.

(E-29) **Power Transmision Equipment**—Catalog, 16 pp. Specifications and ordering information for flexible couplings,

variable speed pulleys and transmissions, sheaves and belts, motor bases, shaft mounted gear reducers and universal joints. Lovejoy Flexible Coupling Co, 4835 W Lake St, Chicago 44, Ill.

(E-30) Gearmotors—Bulletin, 5 pp. Induction type gearmotors for substantial power at slow speeds; five sizes, enclosed or open gearcase. Also, high frequency motor and generator equipment. Motorsearch Co, 1600 Junction Ave, Racine, Wis.

(E-31) Miniature-speed Reducers—Bulletin, 4 pp. Describes construction of miniature speed reducers, applications and fixed ratios available. Metron Instrument Co, 432 Lincoln St, Denver, Colo.

(E-32) Automatic Centrifugal Clutch — Bulletin, 4 pp. Describes construction and gives application data. Fairbanks-Morse, Magneto Div, Beloit, Wis.

(E-33) Flexible Shafting—Catalog, 12 pp. Shows sizes of standard flexible shafts for power transmission with full scale drawings and complete specifications. B W Elliott Mfg Co, Inc, 216 Prospect Ave, Binghamton, NY.

(E-34) Crown Gear—Catalog, 6 pp. Description covering standard models plus charts showing dimensions, capacity, weights, gear ratios, materials, cutaway view, and suggested applications. Crown Gear, 320 Park Ave, Worcester, Mass.

(E-35) Fhp Gearing—Brochure, 6 pp. Describes and illustrates types of precision fhp gears, shafts, rods, cams, ratchets, and others. Shows production facilities and equipment, diametral and circular pitch tables. Gear Specialties, Inc, 2635 Medill Ave, Chicago 47, Ill.

(E-36) Over-running Clutches—Catalog, 26 pp. Describes construction and applications; gives engineering, ordering, installation and maintenance data. Formsprag Co, 23601 Hoover Rd, Warren, Mich.

(E-37) Centrifugal Clutch—Catalog, 16 pp. Describes applications, installation and removal instructions, mounting arrangements, how to order, and operation of an automatic centrifugal clutch and clutch coupling. Formsprag Co, 23601 Hoover Rd, Warren, Mich.

(E-38) Clutches and Converters—Catalog, 72 pp. Detailed specifications and line drawings; design features described and illustrated. Includes service instructions, performance curves, ratings, dimensions, dismantling and reassembly procedures. Borg & Beck Div of Borg-Warner Corp, 6558 S Menard Ave, Chicago 38, Ill.

(E-39) Mechanical Power Transmission Equipment—Bulletin, 20 pp. Complete torque and hp ratings as well as dimensional data for extensive line of single and three stage torque converters, fluid couplings, power takeoffs, reduction and marine reverse gears; air, oil and manually actuated clutches. Twin Disc Clutch Co, 1328 Racine St, Racine, Wis.

(E-40) V-drives—Bulletin, 44 pp. Explains construction features of sheaves and v-belts. Includes tables of preengineered drives. Dodge Mfg Corp, S Union St, Mishawaka, Ind.

(E-41) Slow-speed Motors—Bulletins, 2 pp. Gives specifications of construction, speeds, ratings and ordering information for spun and worm slow-speed motors. Brevel Products Corp, 601 W 26th St, New York 1, NY.

(E-42) Electric Clutch—Bulletin, 4 pp. Includes description of how the clutch with stationary coil works. Drawings, specification features, applications, statistical chart and driving cup information. Carlyle Johnson Machine Co, 52 Main, Manchester, Conn.

(E-43) Magnetic Drive—Brochure, 8 pp. Describes design principle and construction details; gives selection tables, dimensions, drive accessories and typical applications. Whitney Chain Co, 237 Hamilton St, Hartford, Conn.

(E-44) Plastic Core Belting—Catalog, 8 pp. Describes construction and capabilities: high load, speed and shock absorbing capacity, and others. Additional sections on significant applications, proper selection of belt type and tensioning. Extremultus, Inc, 25-11 40th Ave, Long Island City, NY.

(E-45) Gearmotor—Brochure, 6 pp. Provides torque and output speed ratings for sub-fractional hp skeleton and gear reduction motor, plus physical dimensions and mounting accommodations. Molon Motor & Coil Corp, 2432 W George St, Chicago, Ill.

(E-46) Power Transmission Products — Catalog, 640 pp. Contains information on 9496 standardized power transmission products. Over 50 pages of engineering data are included. Boston Gear Works, 14 Hayward St, Quincy 71, Mass.

(E-47) Flat Belting—Bulletin, 4 pp. Reasons for using plastic core belting, engineering data, and formulas for design. Graton and Knight, 356 Franklin St, Worcester 4, Mass.

(E-48) Gear Units—Bulletin, 6 pp. Gives dimensions, capacity, features and applications of standard models and data on custom made variations. Crown Gear Div of Harrington & Richardson, Inc, 320 Park Ave, Worcester, Mass.

(E-49) Adjustable-speed Drive—Bulletin, 6 pp. Illustrates construction features. Gives applications, engineering information and dimensions. Rating 1–20 hp, speed ranges up to 8:1. The Louis Allis Co, 427 E Stewart St, Milwaukee 1, Wisc.

(E-50) Industrial Clutches and Brakes—Bulletin, 32 pp. Air, over-center clutches and interconnected brakes are described with engineering information, sizes and product sketches. Industrial Clutch Corp, 515 Frederick St, Waukesha, Wis.

(E-51) Roller Chain and Sprockets—Catalog, 86 pp. Engineering and stock catalog information on roller chains, sprockets and flexible couplings. Cullman Wheel Co, 1344 Altgeld, Chicago 14, Ill.

(E-52) Variable-speed Drive—Brochure, 12 pp. Specifications and engineering data on drives from ¼ hp to 1½ hp. Practical control arrangements for local, remote reverse, and dynamic braking operations are presented. Magnetic Amplifiers, Inc, 632 Tinton Ave, NY, NY.

(E-53) Power Transmission Products—Bulletin, 12 pp. Descriptions, illustrations and brief selection tables on mechanical power transmission equipment. Worthington Corp, Oil City, Pa.

(E-54) Transmission Units—Catalog, 4 pp. Listing of standard items such as pulleys, flexible couplings, pillow blocks, v-belts and others. Also lists piece weight—as well as functional engineering requirements. Congress Drives Div, Tann Corp, 3750 E Outer Drive, Detroit 34, Mich.

(E-55) Bead Belt Drives—Brochure, 4 pp. Typical applications and descriptions of drives includes plastic bead belts, metallic bead chain, sprockets: machined, molded and die cast. Voland & Sons, Inc, 27 Centre Ave, New Rochelle, NY.

(E-56) Precision Components — Catalog, 416 pp. Describes precision gears, shafts, bearings, collars, plates, differentials, speed reducers, worm and wheel assemblies, magnetic clutches and precision breadboard kits. PIC Design Corp, 477 Atlantic Ave, East Rockaway, N. Y.

(E-57) Clutches and Brakes—Catalog, 9 pp. Gives specifications and dimenisons on standard clutches, brakes, tension and torque control units. Added description of flexible shaft couplings. Dial Products Co, 9 Ave E, Bayonne, NJ.

(E-58 Electro Clutches—Bulletin, 20 pp. Describes basic designs with torque capacities and dimensions. Also gives performance and typical application drawings. I-T-E Circuit Breaker Co, T & R Div, 19th & Hamilton St, Philadelphia 30, Pa.

(E-59) Right-angle Drive—Bulletin, 4 pp. Shows construction, gives advantages and suggests usages. Contains charts and illustrations. Airborne Accessories Corp, 1414 Chestnut Ave, Hillside 5, NJ.

(E-60) Clutch-torque Converter—Brochure, 6 pp. Hydraulically controlled power shift reversing clutch and torque converter for shuttle applications such as road rollers, loaders, and others. Specifications and application data included. Funk Mfg Co, 1211 W 12th St, Box 577, Coffeyville, Kan.

(E-61) Bead Chain—Catalog, 12 pp. Describes sizes, assemblies, and applications. Sketches and photographs are used to illustrate the various products. The Bead Chain Mfg Co, 110 Mt Grove St, Bridgeport 5, Conn.

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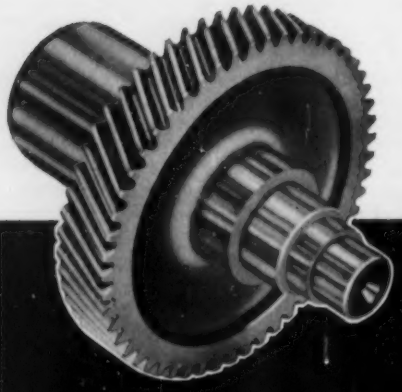

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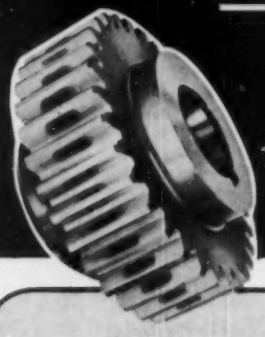

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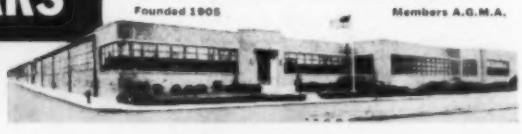

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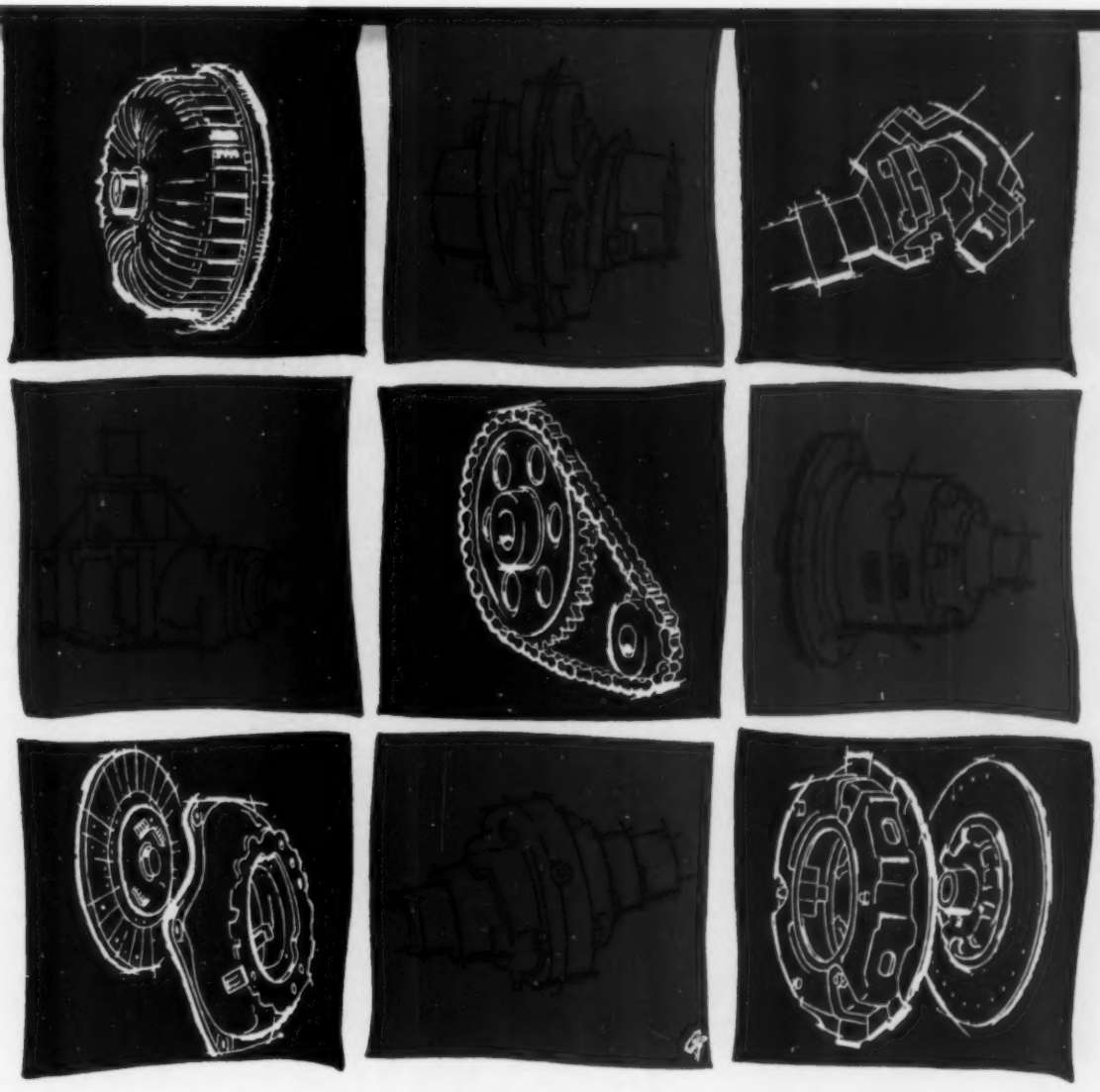

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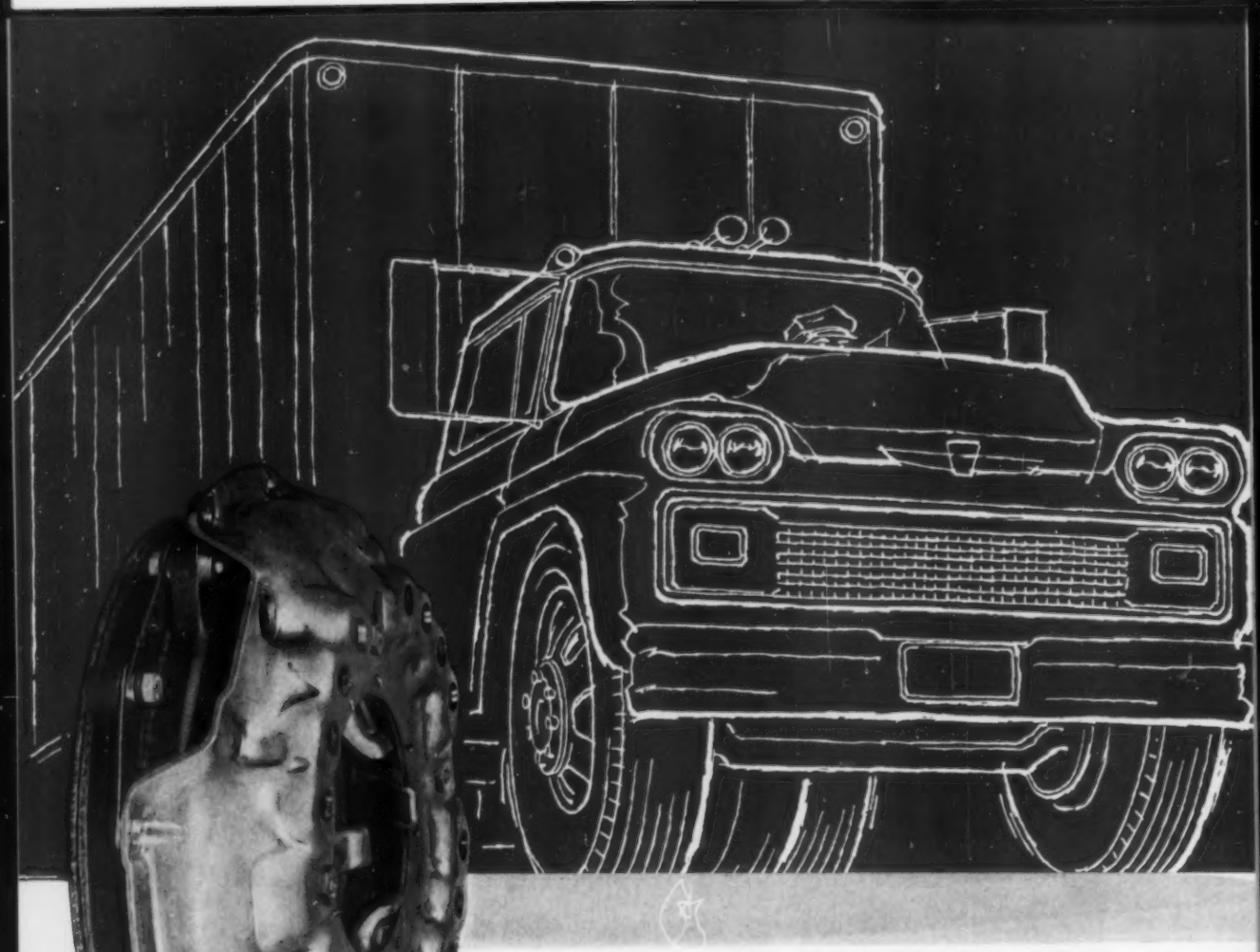

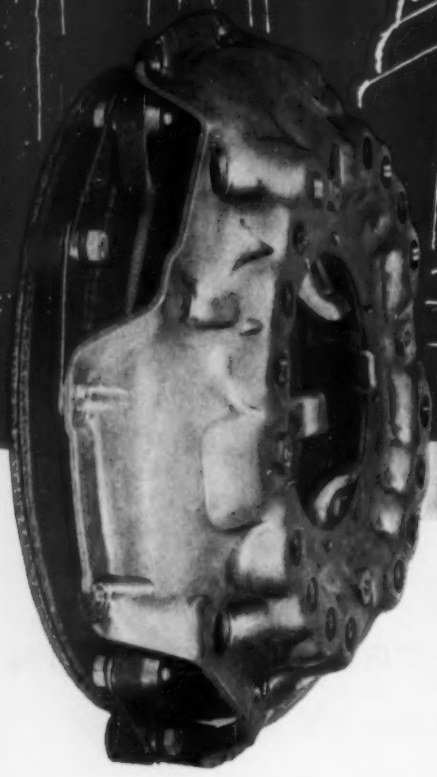

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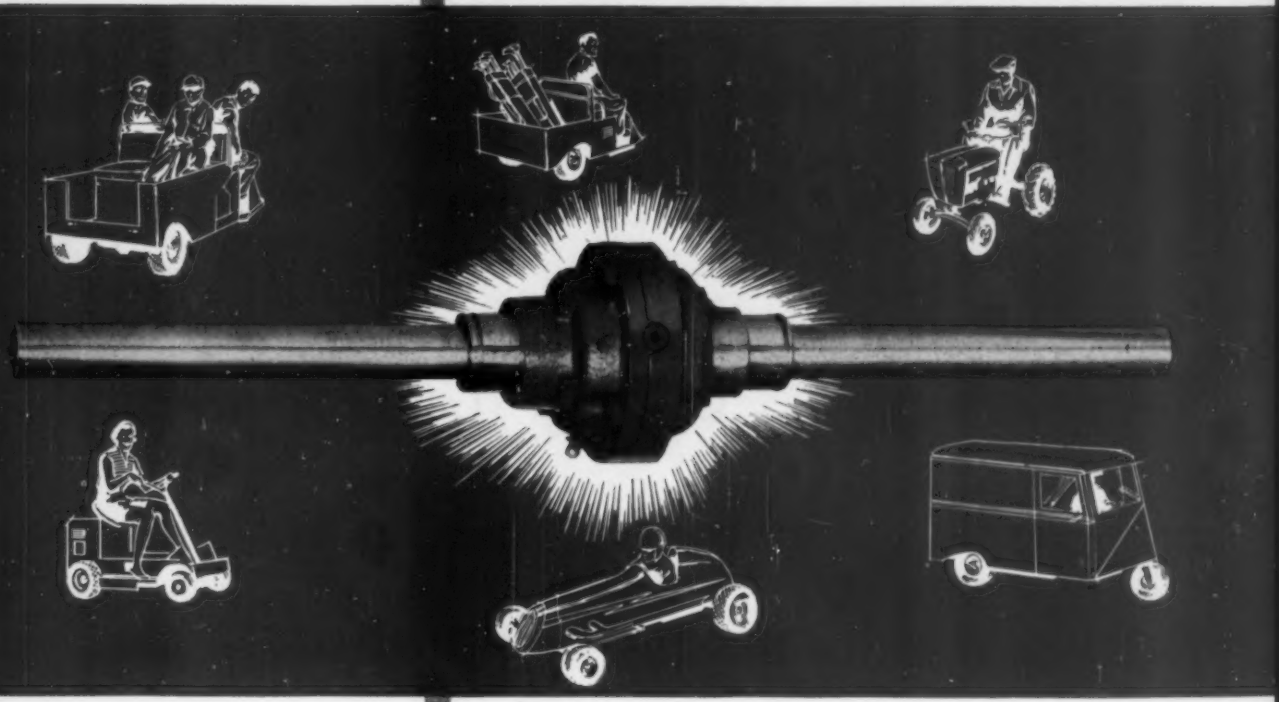

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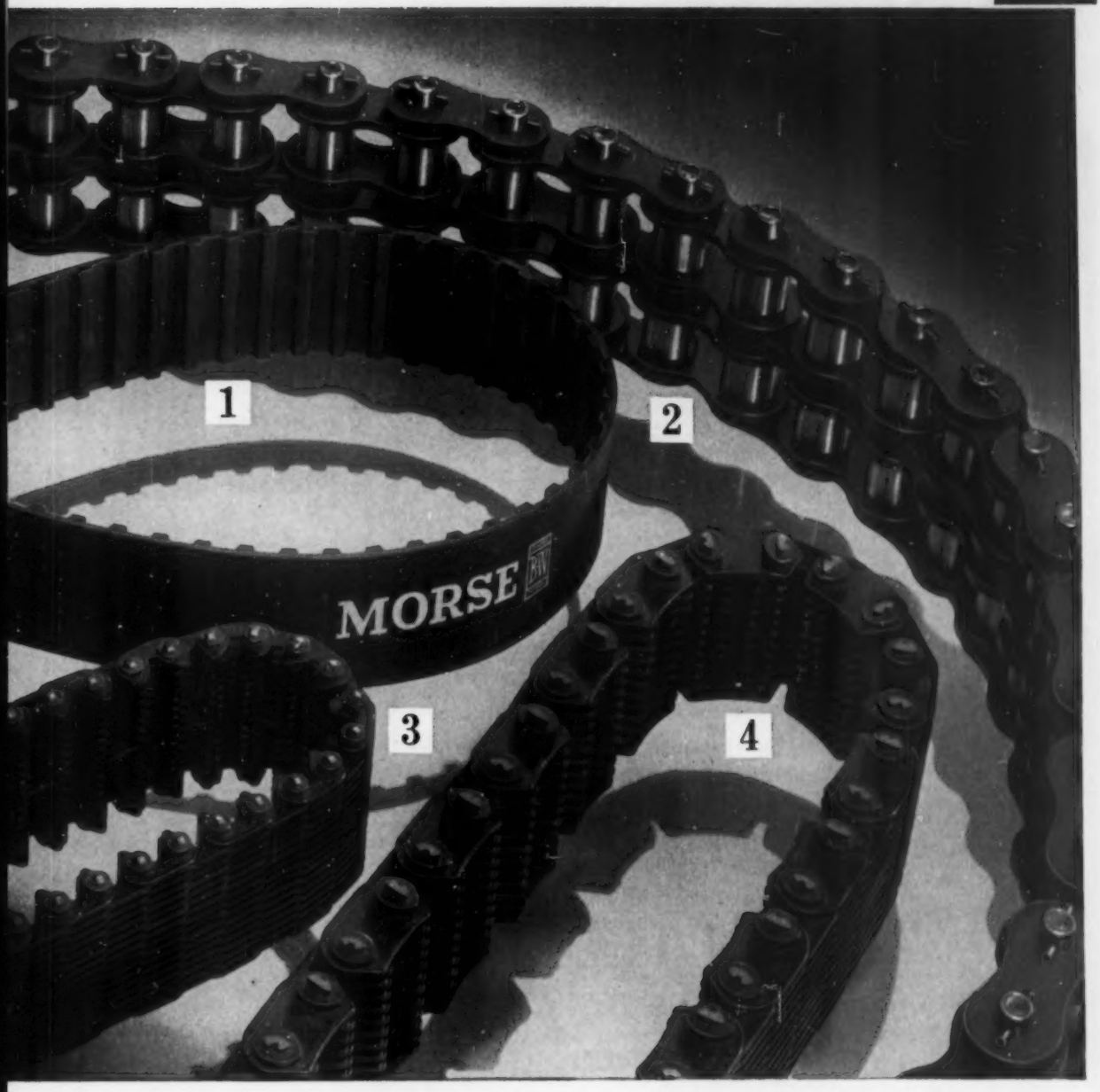

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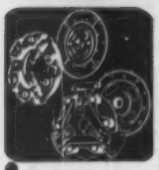
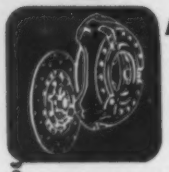
POWER TRANSMISSION

ROCKFORD



Small Spring Loaded Clutches

For foot pedal controlled vehicles and implements. With or without dampener. Cushion type plate. Flat or cupped cover. 6" to 11" sizes. Capacity 50 to 325 foot pounds. S.A.E. Housings.



Automotive Spring Loaded Clutches

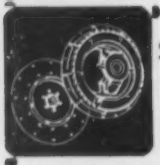
For foot pedal controlled automotive vehicles where cushioning is required for starting and shifting gears. Single dry plate. 8" to 15" sizes. Capacity 100 to 1000 foot pounds. Standard S.A.E. housings.

Heavy-Duty Spring Loaded Clutches

For tractors and pedal controlled vehicles requiring starting and shifting cushioning. Single or double dry plate. 11" to 16" sizes. Capacity 300 to 1950 foot pounds. Standard S.A.E. housings.

Morlife® Spring Loaded Clutches

For heavy duty off-the-road machines requiring cushioned engagement. Single or double plate. 12" to 16" sizes. Capacity 600 to 2530. S.A.E. standard housings.



Spline-Drive Over-Center Clutches

For machines requiring long periods of locked-in roller cam controlled engagement or disengagement. Single or double plate. Oil or dry operation. 8" to 16" sizes. 210 to 1630 foot pounds capacity. Standard S.A.E. housing.

Gear-Drive Over-Center Clutches

For machines requiring "over center" and "release" locked-in position clutching. Roller cam operation. Single or double plate. Resists shock loading. 6½" to 18" sizes. 125 to 3235 foot pounds capacity. Standard S.A.E. housing.

Morlife® Over-Center Clutches

For heavy duty off-the-road machines requiring cam controlled clutches. Single or double plate. 12" to 16" sizes. Single or double plate. Standard S.A.E. housing. Capacity 1500 to 3000 foot pounds.

How to Specify the RIGHT CLUTCH For Your Particular Need

FIRST – Decide what the clutch *must do* to make YOUR product operate most efficiently.

NEXT – Decide the Type, Size, Shape, Strength, Stamina and Work-Life the clutch *must have* to meet YOUR particular need.

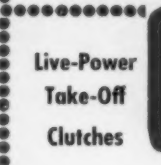
THEN – Let Clutch Engineers contribute their specialized experience to help solve YOUR clutch problem.

ROCKFORD Clutch Engineers will bring you complete information concerning the practical application of any of the clutch types shown here:

SEND FOR THIS HANDY BULLETIN

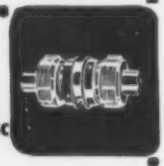
Shows unique ROCKFORD CLUTCH and POWER TAKE-OFF applications. Contains diagrams, dimensions, capacity tables, etc.

ROCKFORD CLUTCH DIVISION BORG-WARNER
209 Catherine Street, Rockford, Illinois, U. S. A.



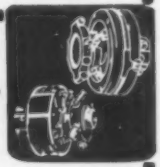
Live-Power Take-Off Clutches

For machines requiring over-center PTO operation, independent of spring-loaded propulsion control. Single, double or triple plate. Capacity 120 to 400 foot pounds.



Single or Double Oil or Dry Multiple-Disc Clutches

For machines requiring powerful, hand operated control, within limited space. Capacity 126 to 11,000 inch pounds. 1-11/16" to 8¾" diameter. 2½" to 9¾" length.



Light Over-Center Clutches

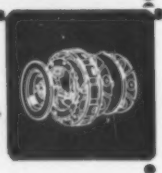
For machines requiring toggle-type, Over-center, belt, sprocket, thru-shaft or cut-off coupling drive. 3½", 4½", 5½" sizes. Capacity 360 to 1080 inch pounds.

Heavy Duty Power Take-Offs

Complete self-contained units. Gear tooth, over-center clutches. Capacity 125 to 3000 foot pounds. Organic or Morlife clutch facings. No. 00, O, 1, 2, 3, 4, 5, 6 S.A.E. housings.

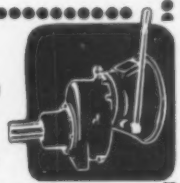
Over-Center Air-Flow Morlife® Clutches

For heavy-duty service .15" Spline-drive type. Maximum air cooling. Over-Center cam action. 1440 foot pounds torque capacity.



Double Plate Over-Center Clutches

For large, crawler type tractors where high torque capacity is required in limited space. Brake plate mounted on ball bearing type release sleeve. 16" Over-Center size. Capacity 1630 foot pounds.



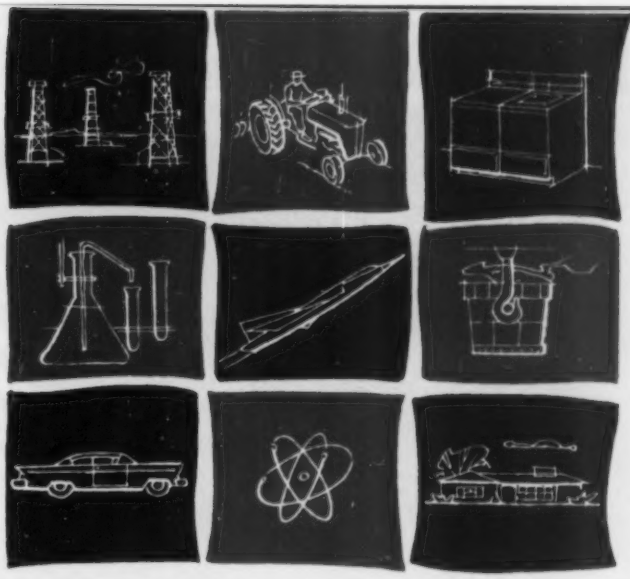
Gear Reduction Speed Reducers

Incorporate a heavy duty power take-off and a gear reduction in one unit. Used where output shaft speed is to be slower than engine speed. 125 to 1850 foot pounds capacity. Standard S.A.E. housing.

CLUTCHES

BORG-WARNER

SERVES MANY INDUSTRIES WITH HUNDREDS OF PRODUCTS



Engineered and Produced by These Divisions and Subsidiaries . . .

ATKINS SAW—hand, crosscut, circular and band saws; hacksaw blades; chainsaw chains; machine knives; clutch discs.

BORG & BECK—automotive clutches and torque converters.

BORG & BECK do BRAZIL, S.A.—automotive clutches.

BORG-WARNER (AUSTRALIA), LTD.—automotive transmission and differential assemblies, gears, gear sets, and axle assemblies.

BORG-WARNER INTERNATIONAL—foreign operation, overseas licensing and export for all Borg-Warner products.

BORG-WARNER, LTD.—automatic transmissions, overdrives, automotive timing chains and sprockets; industrial silent chains and sprockets; roller chains and sprockets.

BORG-WARNER SERVICE PARTS—national distributors of replacement automotive parts.

BYRON JACKSON—agricultural and industrial centrifugal and turbine pumps; nuclear pumps; oil field products and services; electronic instruments; marine bearings.

BYRON JACKSON OF CANADA, LTD.—centrifugal pumps and mechanical seals.

BYRON JACKSON CO., S.A.—centrifugal pumps and oil tool products.

BJ SERVICE OF CANADA, LTD.—oil well cementing and formation testing.

BJ SERVICE, INC.—cementing, acidizing, fracturing and other oil field services.

CALUMET STEEL—steel fence posts; concrete reinforcing bars; structural steel tubing, steel shapes, channels, angles, bars.

CELLO PRODUCTS, LTD.—brass soldered fittings for use with copper pipe, soldered stops and drains.

FRANKLIN STEEL—steel fence posts; concrete reinforcing bars; merchant bars (rounds, flats, angles, special sections).

INGERSOLL-HUMPHRYES—enameled cast iron and steel bathroom fixtures and fittings; vitreous china water closets and lavatories.

INGERSOLL KALAMAZOO—amphibious landing vehicles; guided missile boosters; materials handling equipment.

INGERSOLL PRODUCTS—tillage discs and other farm implement parts; automotive stampings; washing machine tubs; porcelain enameled steel sinks and bathtubs; architectural porcelain paneling; carbon and alloy steel plate; cranes and hoists.

INGERSOLL STEEL—special purpose steels; forging quality ingots; automotive and tractor clutch discs; tillage discs; hand shovels, spades and scoops.

LONG MANUFACTURING—automotive torque converters, clutches, radiators, oil coolers, heater coils, cooling and condensing coils and precision stampings; domestic heating, cooling and condensing coils; industrial and commercial fluid torque converters, clutches and converter assemblies.

LONG MANUFACTURING CO., LTD.—see Long Manufacturing.

MARBON CHEMICAL—rubber-to-metal adhesives; synthetic and high impact thermoplastic resins.

MARVEL-SCHEBLER PRODUCTS—gasoline, distillate and LPG carburetion systems; power brakes and devices; fuel injection systems; nuclear control rod mechanisms.

MECHANICS UNIVERSAL JOINT—roller bearing universal joints and propeller shafts for automotive, agricultural, aircraft and industrial applications.

MORSE CHAIN CO.—timing, silent and roller chains and sprockets; speed reducers and flexible couplings; industrial free wheeling and indexing clutches; marine propeller shaft couplings.

MORSE CHAIN OF CANADA, LTD.—automotive timing products; industrial and agricultural chain.

NORGE—refrigerators, freezers, ranges, washers, dryers, water heaters; aircraft frame structures; aircraft ground equipment; guided missile airframe structures.

PESCO PRODUCTS—aircraft and missile hydraulic and fuel pumps, valves, electric motors and axial flow fans.

REFLECTAL CORP.—aluminum foil reflective insulation; KoolShade® sunscreen; Betocel lightweight cellular concrete.

ROCKFORD CLUTCH—automotive, industrial and agricultural clutches; power take-off and gear reduction units; heavy duty power-shifting transmissions.

SPRING—torque converter and automatic transmission parts; sprag type clutches; precision springs; multi-slide and punch press stampings; electric motor commutators; special commercial heat-treating.

WARNER AUTOMOTIVE—automotive replacement parts; automotive and industrial gears; conventional and spin-resistant differentials; agricultural and industrial gear boxes; splined shafts; complete gear assemblies.

WARNER GEAR—standard and automatic transmissions, overdrives; marine transmissions; parking brake assemblies; synchronizer assemblies; industrial truck transmissions.

WARNER GEAR CO., LTD.—automotive synchronizer units.

WESTON HYDRAULICS, LTD.—precision hydraulic and pneumatic equipment for aircraft and guided missiles.

WOOSTER—agricultural and industrial hydraulic pumps, valves and power packages.

YORK—commercial, industrial and residential air conditioning equipment; domestic furnaces; mobile air conditioners; ice makers; oil coolers; truck refrigeration.

YORK SHIPLEY, LTD.—see York

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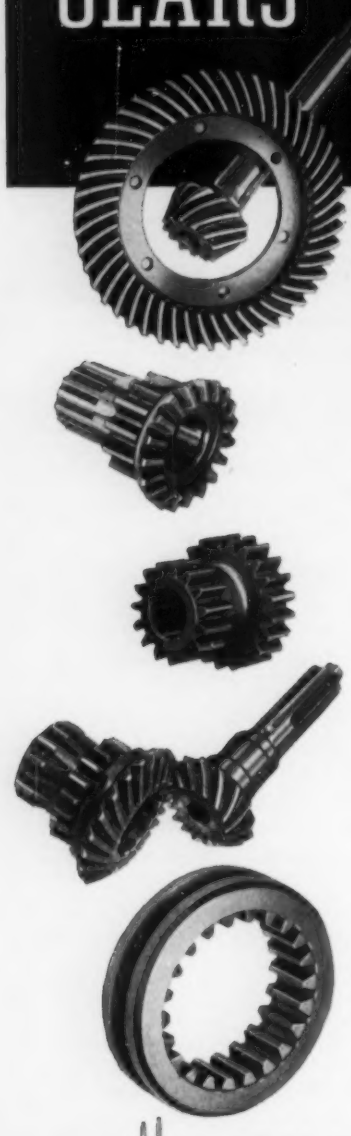
ENGINEERING B-W PRODUCTION

BORG-WARNER®

200 S. Michigan Ave., Chicago 4, Illinois

GEARS *by Fairfield*



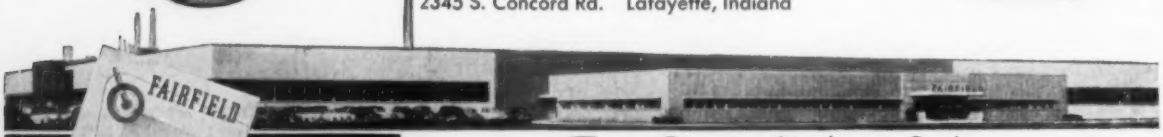
—produced to meet your specifications EFFICIENTLY, ECONOMICALLY!

1. **MASS PRODUCTION ECONOMY**—Large or small, you get the benefits of high production rates and big volume output at Fairfield—where fine gears are produced to meet your specifications EFFICIENTLY, ECONOMICALLY!
2. **QUALITY PLUS**—There is no finer recommendation for the quality of the product you sell than to be able to say it is "EQUIPPED WITH FAIRFIELD GEARS!"
3. **DEPENDABLE SOURCE OF SUPPLY**—Fairfield is one of America's largest independent producers of precision-made, automotive type gears for leading builders of construction, agricultural, industrial, marine, and automotive equipment.
4. **BACKED BY EXPERIENCE**—Unexcelled facilities in an ultramodern plant backed by more than thirty-nine years' experience in producing Spur, Herringbone, Spiral Bevel, Straight Bevel, Hypoid, Zerol, Worms and Worm Gears, Splined Shafts, and Differentials to customer's specifications.
5. **ENGINEERING SERVICE**—Fairfield engineers are qualified to make expert recommendations on your gear production requirements. *Your inquiry will receive prompt attention.*

FAIRFIELD
MANUFACTURING CO.

2345 S. Concord Rd. Lafayette, Indiana

For FINE GEARS



ASK FOR INTERESTING ILLUSTRATED BULLETIN

Fine Gears Made to Order

SPUR GEARS — Straight, helical, and internal. Sizes from 16 pitch, 1½" dia., to 1½ pitch, 36" dia.

HERRINGBONE — (Fellows Type). Sizes from 1½" to 15".

SPIRAL BEVEL — Sizes from 16 pitch, 11½" dia. to 1½ pitch, 28" dia.

STRAIGHT BEVEL — Sizes from 16 pitch, 1½" dia. to 1½ pitch, 28" dia.

HYPOID — Sizes from 1½" to 28" dia.

ZEROL — Sizes from 16 pitch, 1½" dia., to 1½ pitch, 21" dia.

WORMS & WORM GEARS — Worms to 7" dia. Worm gears to 36" dia.

SPLINED SHAFTS — Lengths to 72".

DIFFERENTIALS — 3,000 to 500,000 inch pounds capacity.

Note: All of the sizes above are approximate

HURRICANE-PROOF "OVERCOAT" FOR THE JUPITER...

MISSILE SHELTER-PANELS RAISED

MISSILE SHELTER-PANELS OPEN

"buttoned up" by 24 Saginaw b/b Screws

Buttoning up the "overcoat" for the Jupiter IRBM is a cinch for the Saginaw Ball Bearing Screw! The "overcoat" is a portable prefab standby shelter designed by Barnes & Reinecke, Chicago, and U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., to protect the missile's tail and personnel working on it. The shelter has 12 base sections with hinged panels raised electrically to form a weather-tight seal around the Jupiter's hull.

The Saginaw b/b Screw converts *rotary* motion into *linear* with over 90% *efficiency*. This enables the Saginaw Screws to dependably raise or lower these panels—and hold the shelter securely in place—even in the face of 76 mph hurricane winds. In fact, each Saginaw Screw is able to withstand a combined wind and weight stress of almost five tons! The Saginaw Screw also offers substantial savings in space, power and weight which make the shelter easier to transport and assemble.

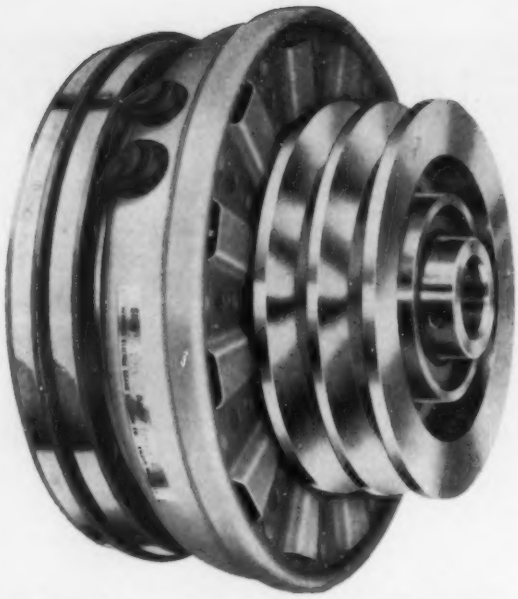
The Saginaw Screw may be able to give *your* products that valuable Sales Appeal you're looking for. To find out, write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*

Give your products NEW SALES APPEAL... switch to the Saginaw ball bearing Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

POWER TRANSMISSION

automatic control and easy jogging economical for any machine



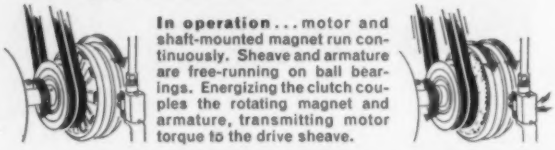
Warner's new Electro-Sheave

. . . adds all the benefits of electric motion control to any motor-driven machine at a practical price.

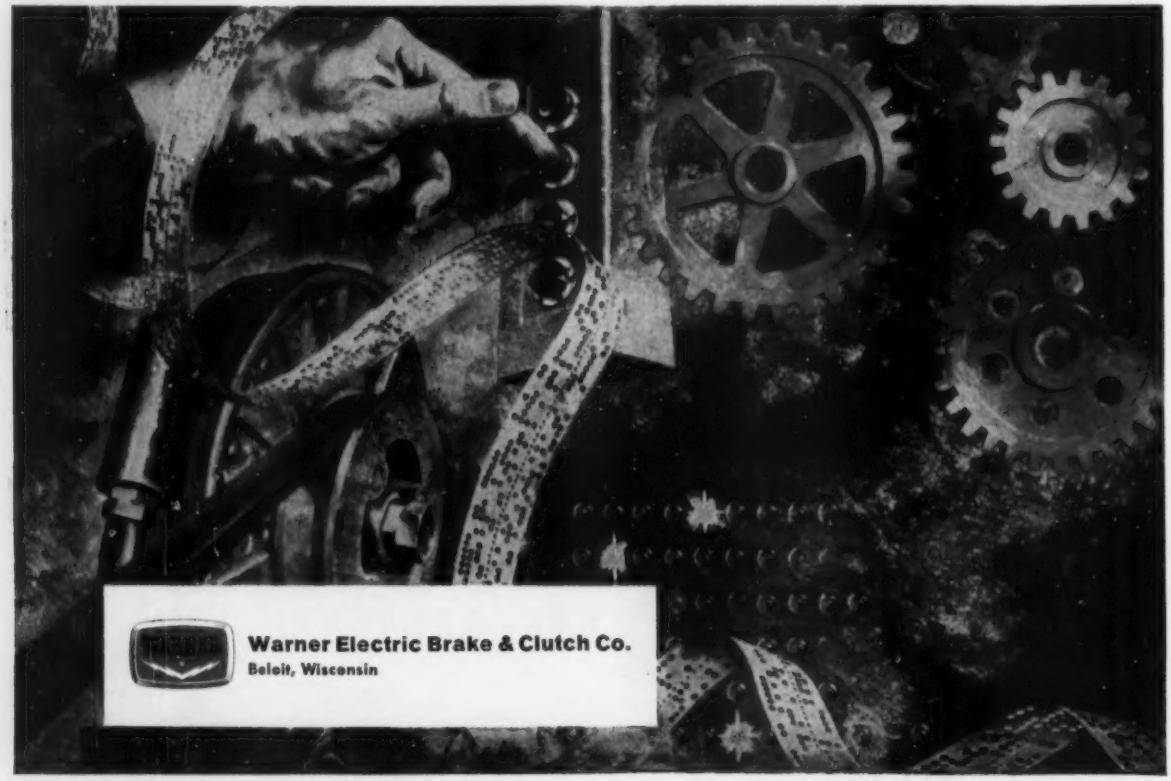
Warner's new combination clutch-pulley package saves you money two ways: 1) It comes to you off the shelf, in one, low-cost, precision assembly. You mount it directly to any standard NEMA motor shaft (new or old)—there is no engineering, machining, or alignment to worry about. Just slip it over the motor shaft, tighten a setscrew, mount the brushholder, belt the sheave to the machine and it's ready to go—in minutes. 2) It simplifies control. Any switch actuates the clutch. Simple wiring to the control panel and brushholder reduces assembly costs, eliminates mechanical linkages, levers, solenoids, and other actuating hardware.

The Electro-Sheave fits right into your design scheme—gives your machines such advantages as faster no-load starting, precise inching and jogging, adjustable torque, automatic control, smaller drive motors, reduced power consumption, and longer motor life. Five sizes (1 to 25 hp) are now available from all Warner distributors. Sheave sizes and styles accommodate most power requirements.

For complete information on installation and operation, including cutaway drawings, description of controls, and selection charts—send for your copy of the new, fully illustrated 10-page booklet, No. P-52.



In operation . . . motor and shaft-mounted magnet run continuously. Sheave and armature are free-running on ball bearings. Energizing the clutch couples the rotating magnet and armature, transmitting motor torque to the drive sheave.



Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

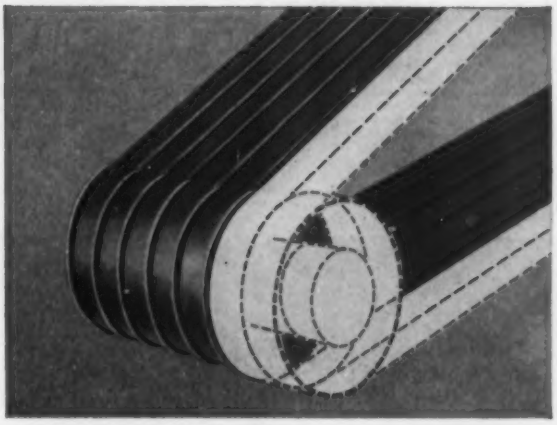
LOWER-COST DRIVES

...one of 3 advantages you can choose from when you specify premium V-belts reinforced with

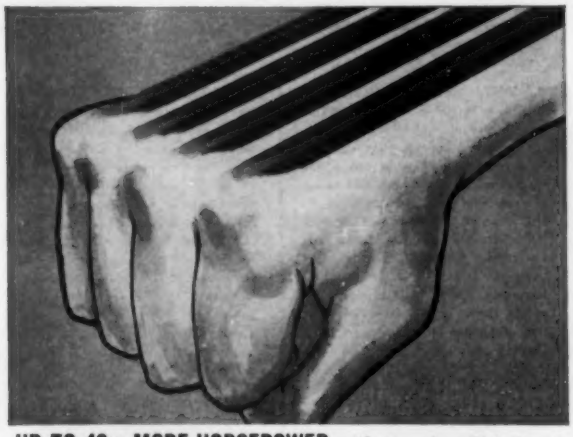
DACRON®

POLYESTER FIBER

DRIVE COST GOES DOWN when your design calls for premium belts made with DACRON. Fewer, stronger belts mean you can use smaller, less-costly sheaves—so total cost is lower.



5 BELTS DO THE WORK OF 7 in a typical drive using premium V-belts reinforced with DACRON. Great strength of DACRON allows freedom of design with fewer or smaller belts and sheaves . . . creates a compact, efficient drive.



UP TO 40% MORE HORSEPOWER with premium V-belts of DACRON makes them ideal for heavy-duty drives. And DACRON is *stable*—has 1/20th the moisture regain of rayon cord used in belts. This simplifies matching problems.

EXTRA STRENGTH in premium V-belts reinforced with Du Pont DACRON* polyester fiber offers solutions to major drive-design problems. Once installed, these belts continue to improve efficiency and economy. V-belts reinforced with DACRON are stable and resist stretch . . . there's less need for maintenance, less time spent in matching.

FREE BOOKLET tells the complete story of V-belts reinforced with DACRON. For your copy, fill out and mail the coupon below. Du Pont makes the DACRON fiber used by belt manufacturers in producing their finest-quality V-belts.

**"Dacron" is Du Pont's registered trademark for its polyester fiber.*

E. I. du Pont de Nemours & Co. (Inc.)
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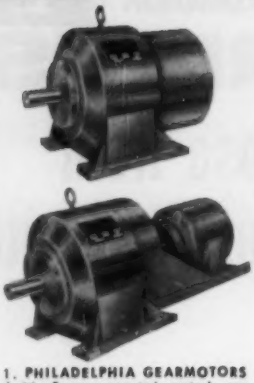
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

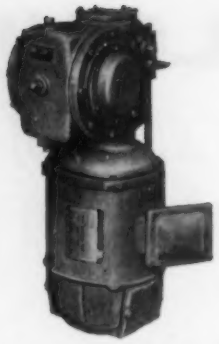


1. **PHILADELPHIA GEARMOTORS** (with flange mounted motor) are available with AC and DC motors to 150 HP in single, double, triple or quadruple reduction. These compact drives provide motor and speed reducer in a single unit. Quick deliveries from stock. Refer to Catalog GM-59.

Utility Gear Motor (with scoop-type motor support) features interchangeability for standard NEMA foot mounted motors without modifications. Available for motors to 200 HP in single, double, triple or quadruple reduction. Ratios to 440:1. Ask for Catalog GM-59.

2. **VERTICAL PUMP DRIVES.** Designed especially for vertical pump drive service. Available in speeds up to 1500 rpm, at ratios from 1:1 to 5.06:1 for ratings up to 1000 HP. Special shaft and auxiliary drive arrangements can be incorporated. The lube oil pump is mounted externally for accessibility. Complete water cooled heat exchanger and oil filter system is also externally mounted. Ask for Catalog SB-57.

3. **HI-SPEED REDUCERS AND INCREASERS** are completely standard units for high speed reduction and speed increaser service. Standard units are designed and built to operate at speeds up to 10,000 rpm, ratios up to 10:1, ranging up to 7100 HP. They have found wide acceptance for use on high speed compressors, generators, pumps and fans. These high speed units are ideal for industrial and Air Conditioning service. Refer to Hi-Speed Bulletin.



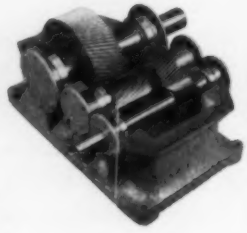
4. **FLOATING GEAR MOTOR** eliminates need for couplings and foundations. Mounts directly on driven shaft without mounting provisions other than a torque arm. Can be mounted in any location or any position. Saves valuable floor and aisle space. Available in single and double reductions offering a wide range of output speeds from 9 to 420 rpm. Any Standard NEMA Flange motor can be used from 1 to 15 HP. Ask for Bulletin F-58.

Whatever your speed reducer requirement . .

7. **IN-LINE REDUCERS** are available in single, double and triple and quadruple reduction types. Can be direct coupled, or driven indirectly. Suitable for normal conditions or severe service as specified. Special shaft seals available for protection against dust or moisture. 26 sizes meet any combination of HP rating or output speed. Standard ratios to 440:1. Refer to Catalog GM-59A.

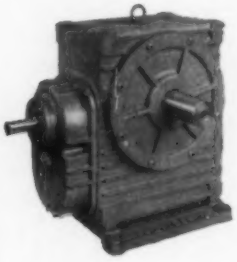
Right angle gearheads can be furnished on any gearmotor, utility gearmotor or in-line reducer. For special applications, a right angle gearhead can be mounted directly on your motor.

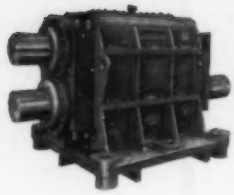
8. **GROUND HELICAL SPEED REDUCERS.** For the first time, speed reducers are available with precision ground gearing. This means you can get commercial reducers with gearing of master gear quality. Reducers can operate at higher speeds. Reduced load factors save weight and space without sacrificing performance characteristics. Sound levels are reduced. Improved accuracy means longer gear life. Backlash is reduced for reversing drives. Available in single, double and triple reduction units. Ratios to 130:1.



9. **SPIRAL BEVEL REDUCERS** are available in single reduction and in double or triple reductions with helical gearing. Standard ratios to 238:1. This reducer finds wide use where quiet operation and high efficiencies are desired. Heavy duty output shafting, oversize bearings, gears of best materials, and adequate oil reservoir for proper lubrication assure long, quiet operation with minimum maintenance. Dry well construction for output shafts in vertical down position eliminates oil leakage. Ask for Catalog SB-57.

10. **WORM GEAR SPEED REDUCERS.** New high efficiency high capacity worm gear drives. Helical attachments for double and triple reduction units combine efficiency advantages of helical gearing with high ratio advantages of worm gearing. Higher capacity means space savings to 50% . . . weight savings to 60%. Horizontal or vertical mounting, all drive arrangements available. Torque attachments for overload protection. Ratios from 5⅓:1 to 12.2:1. Center distances from 3" to 21". Write for information.



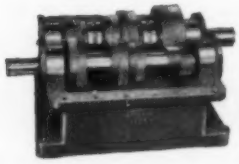


5. **SPECIAL DRIVES.** This illustration shows a steel mill pinion stand—one of the many special enclosed gear drives made to our customer's specifications. This unit obtains 3000 HP at 150 rpm. Whatever your special reducer needs are, Philadelphia Gear can meet all the requirements necessary for the positive, economical transmission of power, with simplicity and high efficiency. Have a special requirement in mind? We'll be glad to quote. Please write on your business letterhead.

6. **PHILADELPHIA GEARS.** Because no one type of gear will best suit every power transmission requirement, we are set up to make all types in sizes to 150" dia. Precision ground gearing available in sizes to 72" dia. Maximum sizes are: Spur, Helical and Double Helical to 150" P.D.; Herringbone to 60" P.D.; Straight Tooth Bevel to 96" P.D.; Spiral Bevel and Zerol to 72" P.D.; Hypoid to 48" P.D.; Worm Gears to 140" P.D.; Worms to 12" P.D.; Internal Gears—spur to 135" P.D.; Racks to 108" length. Ask for catalog G-127.

. . . CALL YOUR NEAREST PHILADELPHIA GEAR OFFICE . . .

11. **CHANGE SPEED GEAR UNITS** are used in many varied industries. Available with 2, 3 or 4 gear combinations for increase or reduction of output speed, these units feature a clutch lever of the involute spline type. Other types of clutches are available upon request. Oil cooling systems are applied when HP transmitted exceeds thermal HP of unit. Standard ratios range up to 5:1. Special two speed ratios can be obtained up to 55:1. Ask for Bulletin CSU-54.



12. **VERTICAL IN-LINE MOTOREDUCER**—Here's real design flexibility. And here's simplification of your drive problems—plus substantial savings in space. The new Philadelphia Vertical Motoreducer offers straight-through shaft arrangement, with motor and reducer vertically in line. Result: tremendous adaptability where horizontal motor arrangements or right angle drives are difficult to install. Capacity up to 400 hp with ratios to 86.5:1. Ask for Catalog MR-58.

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Gardena,
Faculty 1-0346

McCarthy-Hood & Assoc.
1485 Bayshore Blvd.
San Francisco 24,
Juniper 6-1860

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1700—15th Street
Denver,
Main 3-3221, Ext. 20

CONNECTICUT
Kenneth F. Thomas Co.
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Adams 3-8547

DISTRICT OF COLUMBIA
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Washington 6, D. C.
District 7-3309

FLORIDA
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Minich-DuVon Corporation
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philadelphia gear drives

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...the most complete line of standard models and sizes for every design requirement

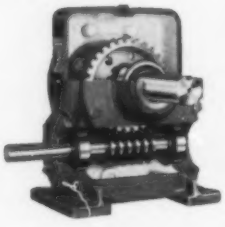
The Winsmith line of conventional and hollow shaft speed reducers offers design engineers and speed reducer users the widest range of standard models and capacities available from a single source of supply.

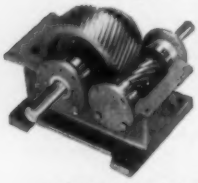
For precise, dependable performance — top operating efficiency at all speeds and ratios — maintenance-free durability and overall economy, specify Winsmith Speed Reducers for every application from 1/100 to 85 h.p., in ratios from 1.1:1 to 50,000:1.

IF YOU HAVE A SPECIAL PROBLEM – consult the Winsmith Representative in your area, or write directly to our Engineering Department.

WORM GEAR REDUCERS

Single or double reduction models, for service in either intermittent or continuous operation. Available with right-angle or parallel shafts; worm on top or bottom; all worm gear or combined worm and helical.



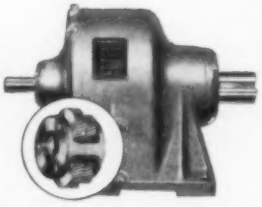


HELICAL GEAR REDUCERS

Single reduction, parallel shaft units for small ratios. Hardened, accurately ground, alloy steel pinion shafts. Cast iron gears.

DIFFERENTIAL GEAR REDUCERS

Winsmith offers a unique, patented type of differential gear reducer in which the planetary and secondary gears are integrated to form a unified planetary element. Tooth alignment is improved because the planetary gears automatically float into position, thus equalizing load distribution. Parts are never increased in number, regardless of reduction ratios—from 1.1:1 to 50,000:1—and the over-all dimensions of a given size never vary.



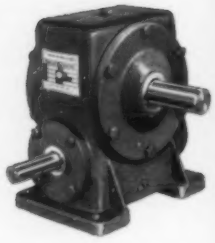
SINGLE REDUCTION WORM GEAR TYPE

SERIES CB, CT, CV

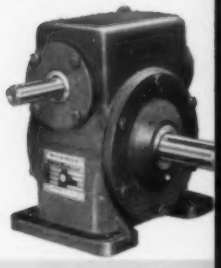
14 Sizes — .01 hp to 34 hp

Ratio Range — 5:1 to 77:1

Maximum Output Torque 142 to 34,767 in. lbs.



CB—WORM ON BOTTOM



CT—WORM ON TOP

CV—VERTICAL

COMPLETE ENGINEERING DATA AND SELECTION INFORMATION FOR YOU

CATALOG NO. 155 — One of the most useful tools ever devised for design engineers. It contains complete selection information: weights, dimensions, parts, ratios and ratings, plus selection factors, lubrication charts, character of load tables, and a complete engineering section that explains power transmission problems and how to solve them.

CATALOGS SM-57 & HSDR-58 — Two supplements to Catalog No. 155, devoted exclusively to Winsmith's new Hollow Shaft Worm Gear Speed Reducers. They contain all the same type of vitally pertinent information, in condensed form.

WRITE TODAY — on your company letterhead, please — for all these catalogs. Together, they are the most authoritative and up-to-date compilation of speed reducer information available.

DOUBLE REDUCTION WORM AND HELICAL GEAR TYPE

SERIES CBX, CTX, CVX

10 Sizes — .3 hp to 11.86 hp

Ratio Range — 42:1 to 231:1

Maximum Output Torque 1331 to 34,767 in. lbs.

DOUBLE REDUCTION WORM GEAR TYPE

SERIES CBD, CTD, CVD

12 Sizes — .018 hp to 7.41 hp

Ratio Range — 60:1 to 4460:1

Maximum Output Torque 650 to 34,767 in. lbs.

1. DOUBLE REDUCTION WORM GEAR TYPE

9 Sizes — .006 hp to 7.319 hp

Ratio Range — 25:1 to 3850:1

Maximum Output Torque 146 to 34,290 in. lbs.

2. SINGLE REDUCTION HELICAL GEAR HORIZONTAL TYPE

3 Sizes — .05 hp to 18.86 hp

Ratio Range — 3.06:1 to 12.66:1

Maximum Output Torque 294 to 3682 in. lbs.

3. TWO SPEED REDUCTION WORM AND SPUR GEAR TYPE

2 Sizes — .01 hp to 6.17 hp

Ratio Range — 5:1 to 163:1

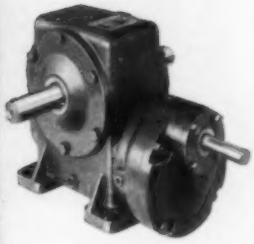
Maximum Output Torque 333 to 3089 in. lbs.

DIFFERENTIAL REDUCERS

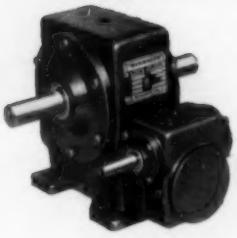
.12 hp to 81.51 hp

Ratio Range 1.1:1 to 50,000:1

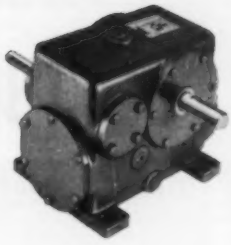
Maximum Output Torque 50 to 113,000 in. lbs.



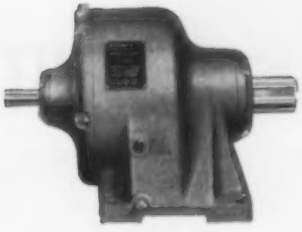
CBX—WORM ON BOTTOM



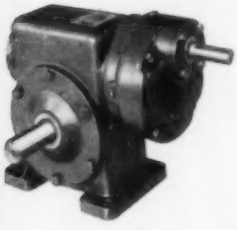
CBD—WORM ON BOTTOM



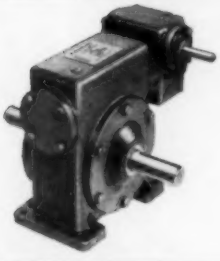
1. SERIES **DBI**



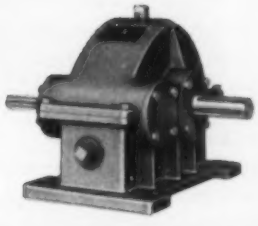
HORIZONTAL



CTX—WORM ON TOP



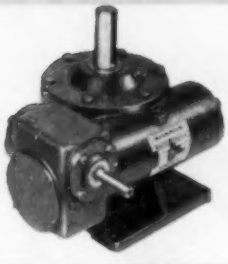
CTD—WORM ON TOP



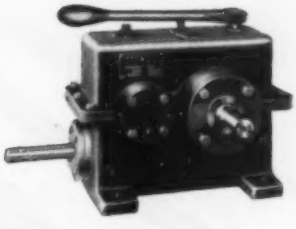
2. SERIES **700, 800, 900**

FLANGE MOUNTED

CVX—VERTICAL



CVD—VERTICAL

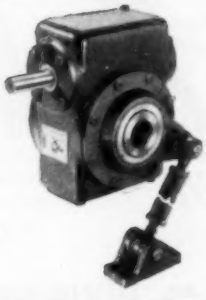


3. SERIES **TSR**

VERTICAL MOTORIZED

HOLLOW SHAFT WORM GEAR SPEED REDUCERS

Torque Arm and Flange Mounted models available in both series.



SERIES "ST" & "SF" Single Reduction

3 Sizes — .63 to 8.82 hp.

Ratio Range — 7½:1 to 77:1

Maximum Output Torque — 816 to 7678 in. lbs.

SERIES "STD" & "SFD" Double Reduction

3 Sizes — .041 to 2.552 hp.

Ratio Range — 66⅔:1 to 4466:1

Maximum Output Torque — 1380 to 7678 in. lbs.

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Simplify design . . . position parts to best advantage . . .
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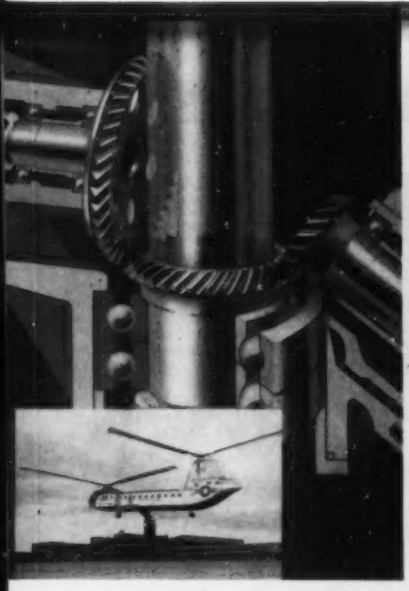
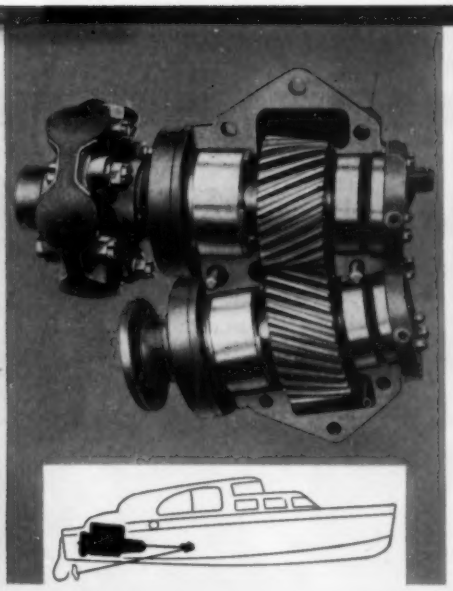
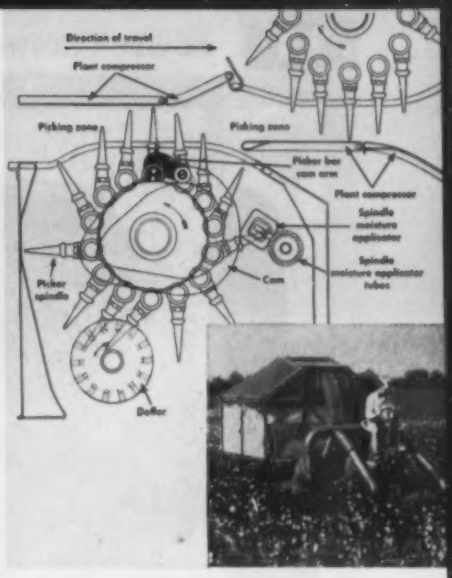
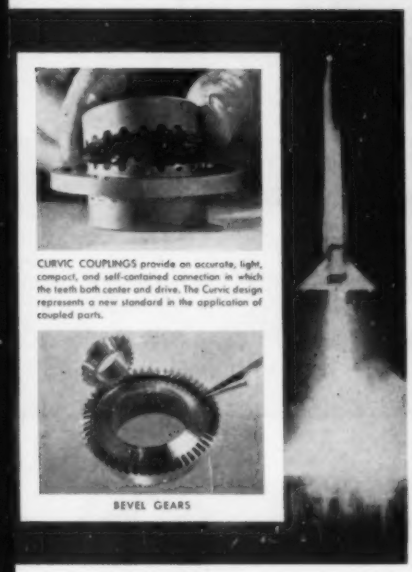


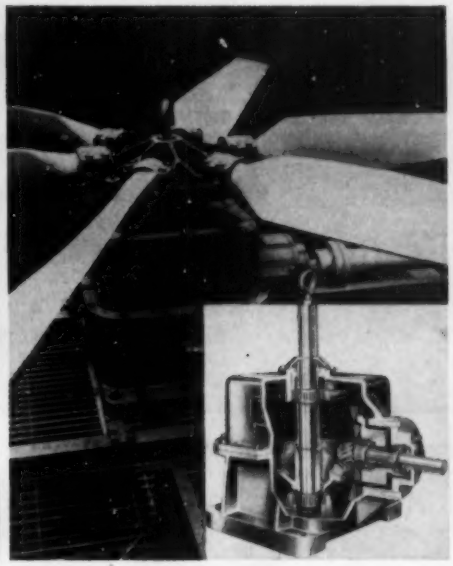






CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.

BEVEL GEARS



What happens when you use right angle or angular drives?

More flexibility. Instead of designing *around* your transmission, you can design a transmission *into* your products with angular drives.

The *helicopter*, for example, is made more compact by having a single drive source service both a blower and a pump. The drive on the *speedboat* gives better balance and more usable cabin space. The *cotton picker* runs fourteen separate picking spindles off one drive member.

Greater accuracy. Using Gleason machines and methods you can grind or cut bevel gears to exceptionally close tolerances. The complete accuracy and reliability needed in the *missile* and *fire control unit* are obvious.

Heavier loads. An angular drive can stay compact and still carry heavy loads such as the one on the gear reducer in the *cooling tower fan*.

Full engineering help. A large and competent staff of Gleason engineers is yours to call on for help in early design work, for the manufacture and testing of prototypes, for selecting and setting up of machines and methods, and for any other assistance you might need.

Free literature. To become better acquainted with the advantages and the theory of bevel gear drives, send for these Gleason Manuals:

20° Straight Bevel Gear System
Spiral Bevel Gear System
Zerol® Bevel Gear System

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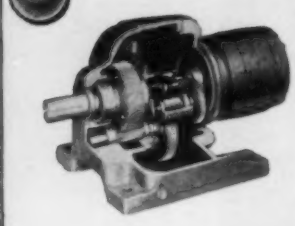
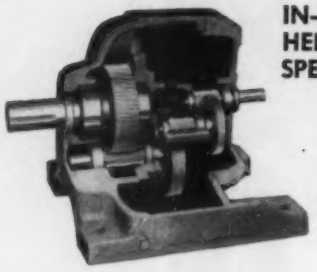


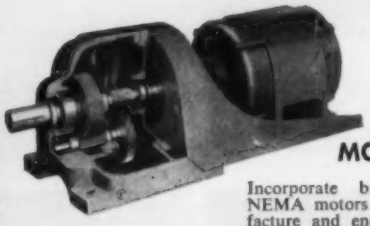
GEARMOTORS

—the ultimate in compactness—maintain positive alignment with flange-mounted NEMA motors. Double, triple and quadruple reductions, sizes up to 100 hp, speeds from 280 down to 1.8 rpm. Send for Book 2747.



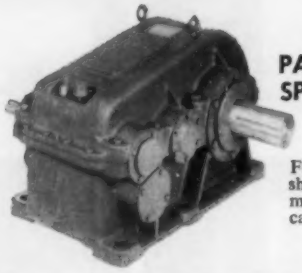
IN-LINE HELICAL GEAR SPEED REDUCERS

let you mount the motor where you want it. Save space with input and output shafts located on same planes. Ratios 6.2:1 to 2217:1, capacities to 206 hp. Send for Book 2751.



MOTOGEARS

Incorporate bracket-mounted NEMA motors of any manufacture and enclosure, permit quick, simple motor replacement. Double, triple and quadruple reductions. Sizes up to 100 hp, ratios from 6:21 to 985:1. Send for Book 2747.



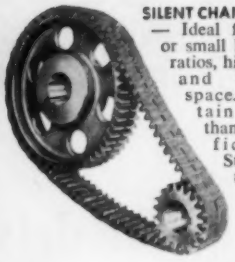
PARALLEL SHAFT SPEED REDUCERS

For high-capacity, heavy shock loads. Ratios to more than 300:1 and hp capacities to over 2000.

Whatever you need in power transmission . . .

complete

CHAINS AND SPROCKETS



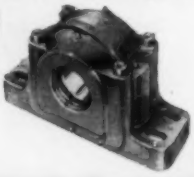
SILENT CHAIN DRIVES — Ideal for large or small hp, large ratios, high speed and limited space. Maintain better than 98% efficiency. Stock sizes up to 50 hp. Ask for Book 2425.

MALLEABLE IRON, PROMAL, STEEL CHAINS — Complete line of cast, combination, forged and fabricated chains plus matching sprockets. Stock sizes. See Book 1050.

PRECISION STEEL ROLLER CHAINS — For drives and conveyors, available in single or multiple widths, in ¼" to 3" pitch and 1" to 3" double pitch. Stock sizes up to 75 hp. Send for Book 2657.

BALL, ROLLER, BABBITTED AND BRONZE BEARINGS

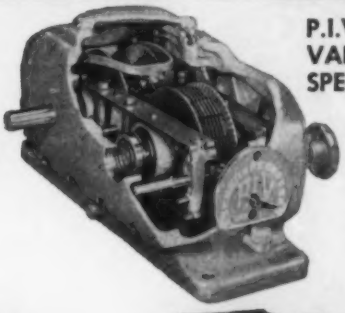
SELF-ALIGNING BALL AND SPHERICAL ROLLER BEARINGS adjust to shaft deflection or misalignment, compensate for normal inaccuracies of mounting. In popular shaft sizes up to 11"—pillow blocks, flanged, flanged-cartridge, cartridge and takeup blocks. Also available in cast and pressed steel housings. Send for Ball Bearing Book 2550 and Spherical Roller Bearing Book 2760.



BABBITTED AND BRONZE BEARINGS —Pillow blocks and flanged blocks are available in 15 different types, solid or split housings, shaft sizes from ½" to 8". Send for Book 2707.

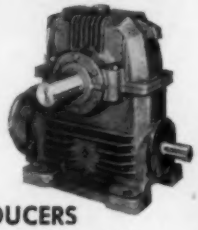
SHAFT-MOUNTED SPEED REDUCERS

Designed to simplify and satisfy the majority of speed reduction jobs. Made in double and triple reductions up to 40 hp. Send for Book 2618.



P.I.V. VARIABLE SPEED DRIVES

Stepless, instant variation through a complete range of speeds. 21 types, 9 sizes from ½ to 75 hp and ratios up to 6:1. Catalogs 2274 and 1050.



WORM GEAR SPEED REDUCERS

—for high-ratio speed reduction with right-angle takeoff. Made with single, double or helical worm gear combinations, ratios 3.1:1 to 8000:1. Book 2824.

UNIVERSAL WORM GEAR SPEED REDUCERS

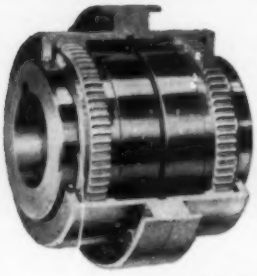
offer 3-way mounting flexibility. Available in 2½-, 3-, 3½-, and 4-in. centers. Sizes up to to 13.5 hp, ratios from 5⅛:1 to 6:1. Book 2724.

FLUID DRIVES

Offer smooth powerful acceleration and operation . . . start heavy loads without excessive power demands . . . protect operating equipment. Available in Fluid, Fluid Gear, Electrofluid Gearmotor and Electrofluid Motogear combinations in single, double, triple and quadruple reductions from 6.2:1 to 985:1 and capacities up to 50 hp. Send for Book 2747.

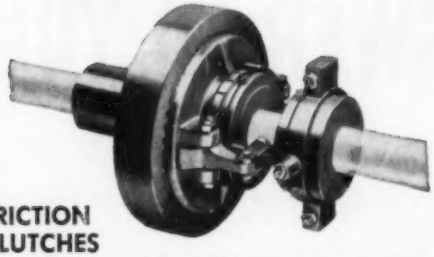
LINK-BELT's complete line gives you

flexibility



COUPLINGS

Flexible, rigid, compression, geared, geared motor, fluid and jaw-clutch types available in shaft sizes from 7/16" up to 12", for light or heavy loads, low or high speeds. Send for RC Flexible Coupling Book 2363; Geared Coupling Book 2775; Geared Motor Coupling Book 2875; All types, Book 1050.



FRICTION CLUTCHES

New design, especially suited where smooth, gradual pickup is a requisite. Available in 3 types with capacities up to 170 hp. Send for Book 2637.

FULL FLEXIBILITY is yours when you rely on Link-Belt. Whether you need a single component or a completely engineered drive, Link-Belt can fit your design requirements to a "T."

Link-Belt standards of quality are built into every component—service-proved designs offering longer life . . . efficiency that means *lower-costs*. What's more, pre-integrated designs assure correct mating of all components for smooth-working efficiency—with no elements under- or over-rated.

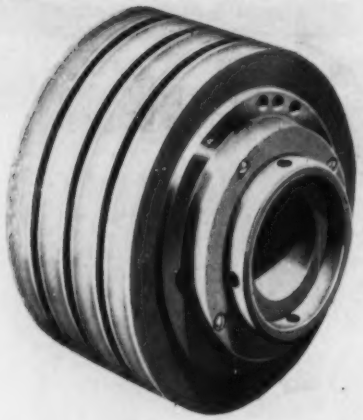
For complete information and literature, call your nearest Link-Belt district sales office.

OTHER LINK-BELT PRODUCTS INCLUDE: cut and cast tooth *gears; shaft collars* in solid or split malleable iron and steel types; *backstops* to automatically prevent backward movement of conveyors and elevators; gray iron and die-crown welded steel *pulleys*.

LINK-BELT

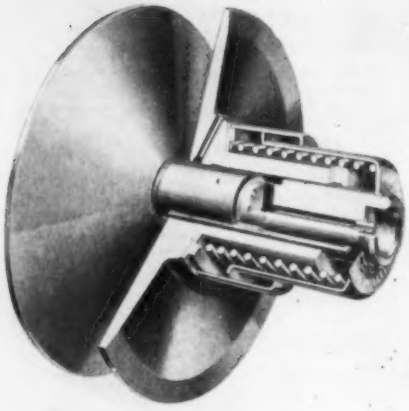
POWER TRANSMISSION MACHINERY

LINK-BELT COMPANY: Executive Offices, Dept. 59-PEDD, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,210



MULTI-PITCH SHEAVES. By adjusting movable flanges, you can provide larger or smaller pitch diameters on these multi-pitch sheaves. The adjustment can be made either when stationary (Stationary Control) or when in motion (Motion Control). They have a speed variation up to 2 to 1 on drives of from 1 to 600 hp. Motor bases are available to compensate for changes in center distances.

SPEED VARIATION 2:1

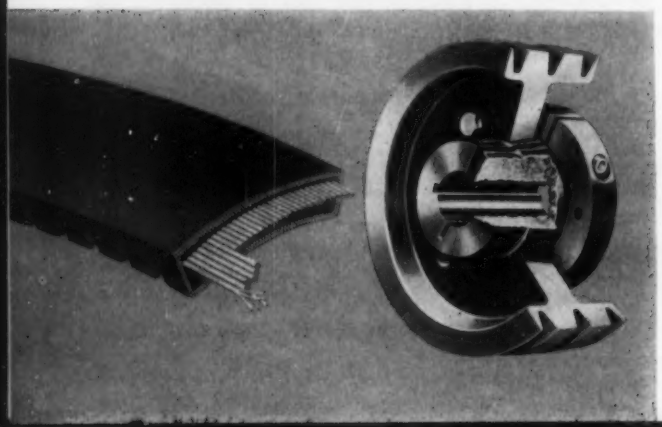


MOTOR PULLEY DRIVES. Worthington's new variable motor-pulley drives combine the efficient power transmission of a V to V drive with the industry's simplest motor-pulley designs for dependable low-cost power transmission with maximum hp. capacities. Ratios 3 to 1 hp. ratings ⅛ to 15. Angle-Matic motor base automatically maintains belt alignment and allows use of true V-groove companion sheave.

3:1

SOMEWHERE ON THIS LINE

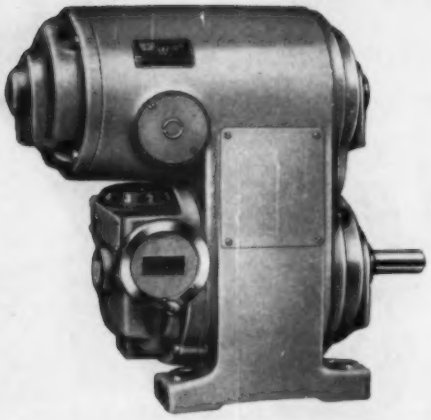
YOU'LL FIND THE ANSWER TO YOUR

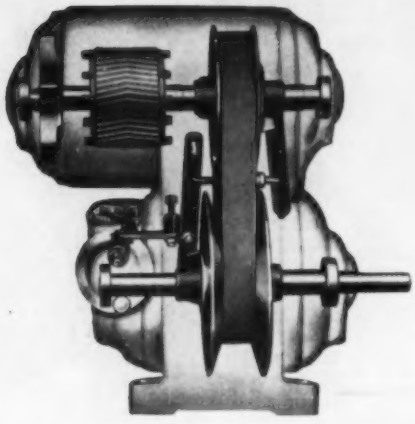


Sound V-belt engineering practice was used throughout Worthington's line of mechanical variable speed drives. They feature compact design, accurate speed control and long belt life.

The line consists of multi-pitch sheaves, motor pulley drives, motor drives, and allspeed drives which handle speed variations up to 20 to 1 and horsepowers from ⅛ to 600.

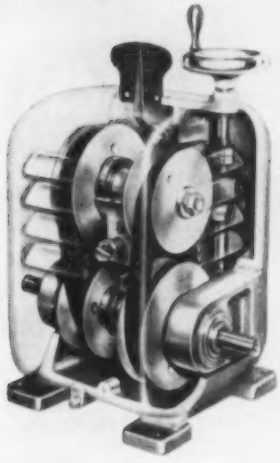
COMPANION SHEAVES AND VARIABLE SPEED BELTS are available from Worthington for use with multi-pitch sheaves and motor pulleys. All companion sheaves are equipped with the famous QD hub with the "Golden Screws." Oil-resistant, static-dissipating construction is standard for all Worthington variable speed belts.





MOTOR DRIVES. Positive pulley adjustment provides accurate speed control. Once you set the speed, the pulley holds it, regardless of varying load. Other benefits include: belt tension in proportion to load, giving extended belt life; compact design and transmission of full rated horsepower. Available in ratings from ½ through 25 hp, with speed variations up to 10:1.

10:1



ALLSPEED DRIVES. Not one, but two belts are used, resulting in an extremely compact unit. This "Twin-V-Tandem" design also gives a very wide speed variation (up to 20:1). Because of positive pulley adjustment, speed control is very accurate. Available in ratings from ⅓ through 5 hp.

20:1

VARIABLE SPEED PROBLEM

For more information about Worthington's complete line of variable speed drives, get in touch with your nearest Worthington representative or distributor. Or mail the coupon at right.

WORTHINGTON

WRITE 241 ON READER SERVICE CARD

WORTHINGTON CORPORATION
Section 79-16, Oil City, Pa.

Please send me your new catalogs on the following variable speed drive components:

- ☐ Multi-pitch Sheaves
- ☐ Motor Pulley Drives (1 to 15 hp.)
- ☐ Motor Pulley Drives (FHP)
- ☐ Motor Drives
- ☐ Allspeed Drives
- ☐ Variable Speed V-Belts

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US RUBBER *PowerGrip* FLEXIBLE COUPLING

GEARED FOR TOP EFFICIENCY AT LOWEST COST

Actual size #42 PowerGrip Flexible Coupling—2 hp. at 1750 rpm., 72 in./lbs. maximum torque. Also available up to 40 horsepower, at 1750 rpm. and torque loads up to 1440 in./lbs.

U. S. PowerGrip Flexible Coupling

- Compensates for greater angular and axial misalignment.
- Installed in minutes by eye. Horizontal or vertical application. No precise measurement required.
- Requires no lubrication, operates silently.
- Eliminates end thrust and shaft vibration.
- Machinery failure cannot harm equipment. Eliminates equipment damage due to overload or jam-up. The coupling disengages itself and can be instantly and inexpensively replaced.
- Costs less, requires no maintenance.

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Your U. S. Power Transmission Distributor has a full stock of all sizes of U. S. PowerGrip Flexible Shaft Couplings. He is your best on-the-spot source for technical aid, quick delivery and quality industrial rubber products.

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PEAK POWER OUTPUT FOR HEAVY-DUTY EQUIPMENT...

HYDRA-DRIVES®

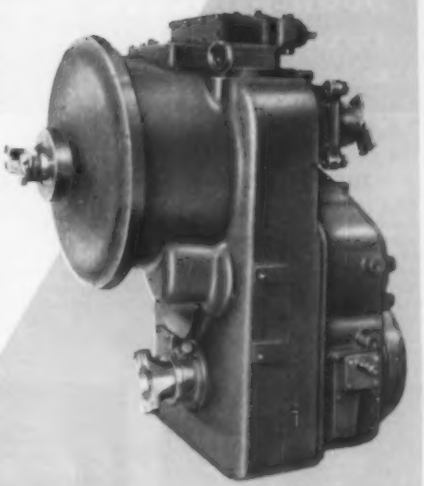
POWER SHIFT TRANSMISSIONS and TORQUE CONVERTERS

Rockwell-Standard's Hydra-Drives units make hard work easy for heavy-duty equipment. The result . . . smooth, efficient, economical operation. A torque converter and 4-speed transmission in one compact package, the Hydra-Drives Power Shift Transmissions have been proved in hundreds of vehicles. They eliminate engine lugging and heavy shock loads. A 3-to-1 torque multiplication makes starting fast and effortless—even with heaviest loads.

Just a flip of the operator's lever accomplishes power shifts without interruption of the power flow. Automatic features of the converter and ease of power shifting simplifies operator training and lengthens vehicle life.

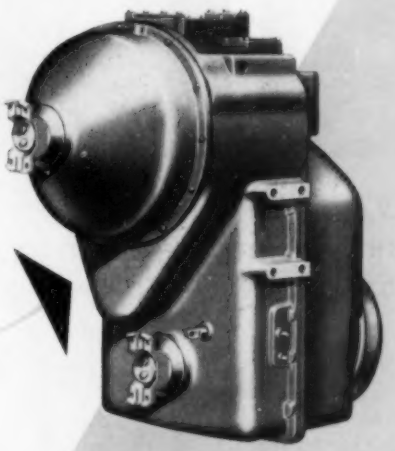
With four speeds forward and reverse, the Hydra-Drives Power Shift Transmissions are ideally suited for vehicles which must travel in both directions during a normal work cycle.

Hydra-Drives Torque Converters are the simplest, most efficient made. They can be matched with any transmission for easier, more efficient operation.



HYDRA-DRIVES BDB Transmission

- Four speeds forward and reverse.
- Full power shifting.
- For equipment up to 175 h.p.



HYDRA-DRIVES CDB Transmission

- Four speeds forward and reverse.
- Power shift in each range both forward and reverse.
- For equipment up to 250 h.p.

HYDRA-DRIVES Torque Converter

- 3-to-1 torque multiplication.
- Available separately, or with Hydra-Drives Transmission.
- For vehicles up to 500 h.p.

HYDRA DRIVES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

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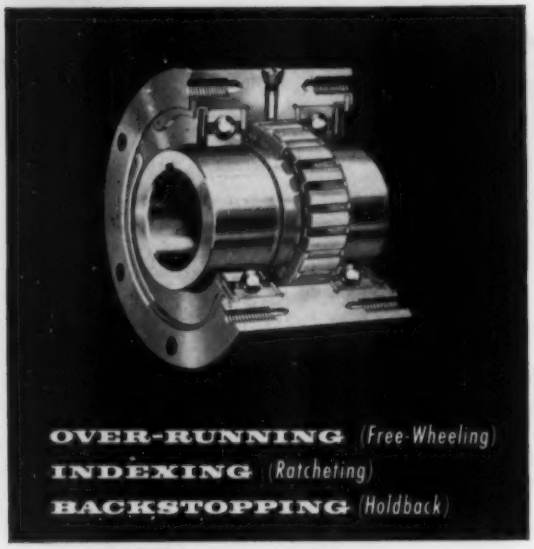


FORMSPRAG OVER-RUNNING CLUTCHES

For Greatest Torque, Precision and Life

The Formsprag clutch consists of a full complement of shaped sprags located between two concentric races. Full torque is transmitted from one race to the other by the wedging action of these precision sprags—there is no lost motion or slipping. Also, the sprags engage at constantly changing contact points—clutch life is lengthened and backlash eliminated. With greater contact in a given annular space, Formsprag clutches transmit more torque in relation to size and weight. Clutch-couplings utilizing Formsprag ball bearing clutches are also available.

SERIES 400 TO 700 CLUTCHES

These clutches are available in standard Formsprag (FS), High-Performance Over-running (HPO) and High-Performance Indexing (HPI) models. Clutches have either labyrinth or mechanical seals as application requires. Maximum Bore Diameters: ½" to 2¾". Torque Capacities: 95 lbs. ft. to 2,500 lbs. ft.

SERIES 750 TO 1000 CLUTCHES

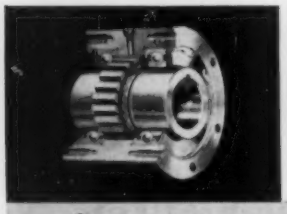
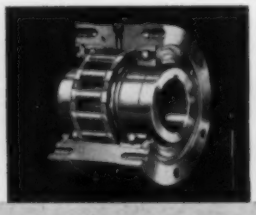
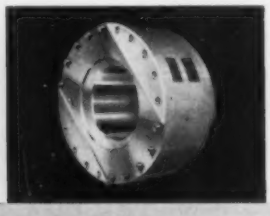
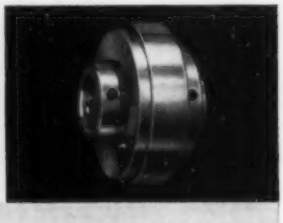
Standard Formsprag (FS), Holdback (HB), High-Performance Over-running (HPO) and High-Performance Indexing (HPI) clutches have either mechanical or labyrinth seals. Maximum Bore Diameters: 2" to 6". Torque Capacities: 1,900 lbs. ft. to 13,500 lbs. ft.

LARGE BORE HOLDBACKS

Formsprag large bore clutches are ideally suited for mounting on head shafts of conveyors or any application requiring high torque over-running features. These backstops can be modified for mountings. Maximum Bore Diameters: 6" to 12". Torque Capacities: 18,500 lbs. ft. to 136,500 lbs. ft.

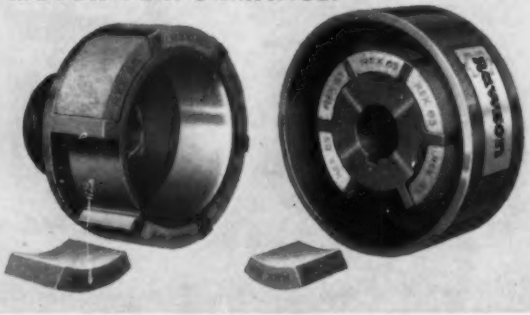
SMALL, LIGHT-DUTY CLUTCHES

Economical light-duty Formsprag clutches transmit maximum torque for their size. These accurate, compact clutches are ideal for business machines, instruments and small industrial machines. Provisions for mounting components such as gears, cams, levers, etc. Maximum Bore Diameters: ¼" to ½". Torque Capacities: 50 lbs. in. to 200 lbs. in.

RAWSON CENTRIFUGAL CLUTCHES & CLUTCH-COUPLINGS FOR CUSHIONED STARTS, OVERLOAD PROTECTION, REDUCED COSTS AND IMPROVED MOTOR PERFORMANCE.

The compactness, reliability and maximum capacity of Rawson Clutches have proven especially effective in aircraft applications such as helicopter transmissions. Used in a wide variety of other applications, Rawson Clutches eliminate costly reduced voltage starting equipment, permit use of lower cost smaller motors and provide full overload protection. Write for your copy of Rawson Clutch Catalog.



For additional information on Formsprag over-running clutches or Rawson centrifugal clutches, write to:

FORMSPRAG COMPANY

23607 HOOVER ROAD, DEPT. 108 • WARREN (DETROIT), MICHIGAN

World's Largest Manufacturer of Over-Running Clutches

STANDARD STOCK GEARS — over 2000 types and sizes

SPEED REDUCERS

HELICAL GEARED REDUCTORS • RATIOMOTORS and Flanged Reductors
for SHAFT MOUNTING or BASE MOUNTED

BOSTON Gear OPTIMOUNT

SINGLE or DOUBLE REDUCTION
1/6 to 15 HP drives
1130 combinations FROM STOCK

BOSTON GEAR 100 SERIES SPEED REDUCERS

1605 types and ratios FROM STOCK

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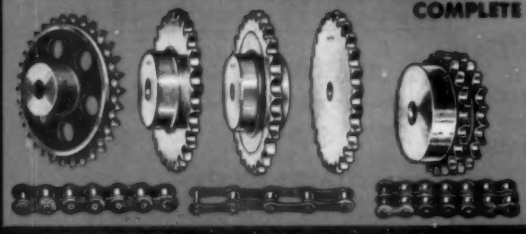
FLANGED REDUCTORS are Ratiomotor gear units sold without motors. You buy and attach your own choice of motors.

SPROCKETS and CHAIN

COMPLETE CHAIN DRIVES 1/4" to 2" PITCH

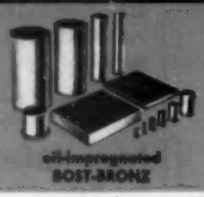


BORED-TO-SIZE SPROCKETS
76 sizes
321 bores
FROM STOCK
ready to install
Complete with keyway and set screw

SHOLD-A-GRIP Interchangeable Tapered BUSHINGS and SPROCKETS

BEARINGS • PILLOW BLOCKS • COUPLINGS

solid bronze BEAR-N-BRONZ



oil-impregnated BOST-BRONZ

BALL BEARINGS Radial-Sleeve

SHAFT SUPPORTS Pillow Blocks Flanged Cartridges

FLEXIBLE COUPLINGS UNIVERSAL JOINTS

NEW Catalog No. 57 lists 9496 STANDARDIZED PRODUCTS
"off-the-shelf" — from local stocks — at factory prices

CALL YOUR BOSTON Gear DISTRIBUTOR

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For nearest Distributor LOOK UNDER "GEARS" in the "Yellow Pages"

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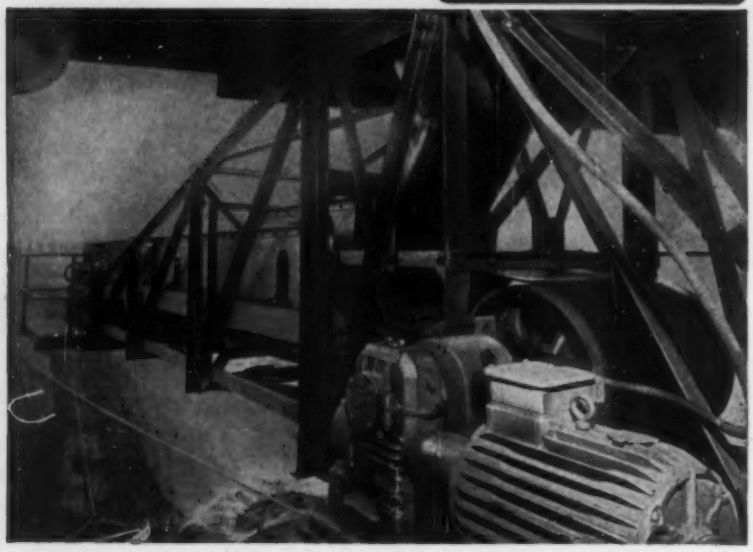
DAVID BROWN

at work around the world



Radicons drive coal feed conveyors at one of England's largest power plants

WHY O.E.M. INSTALLATIONS ACCOUNT FOR 85% OF RADICON SALES

In Europe, Africa, South America, Australia, Canada and the U. S., Radicon speed reducers are harnessing motor speeds into working power for all industry.

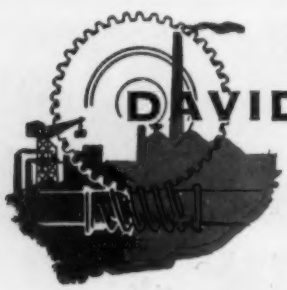
From missile launchers to supermarket check-out counters, product design engineers have come to know the important 1-2-3-4 reasons why Radicons are specified on so many different industrial applications—and why OEM installations account for 85 percent of the David Brown Radicon sales.

1. PRICE—The original equipment manufacturer is always fully protected on the industry's accepted discount, *and* Radicon drives are still competitively priced at the user level.

2. RELIABILITY—Trouble-free operation under all operating extremes.

3. PRODUCT LINE—A Radicon in the size, type and ratio for every job.

4. DELIVERY—Off-the-shelf on Radicons in 14 sizes, 1⅛" to 14", 8 types, 17 ratios from 5:1 to 250:1.



Get the details on the cooperative service of David Brown companies around the world—on the next installation!

DAVID BROWN, INC.
(one of the David Brown Industries)
999 Beecher Street, San Leandro, California
6025 Atlantic Blvd., Maywood, California
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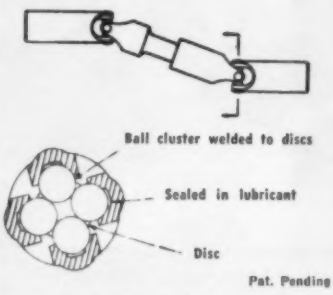
ZERO BACKLASH

GUARANTEED WITH MINI-JOINTS*

(* Miniature Universal Joints)

Telescoping Double Joint with preloaded ball spline now available as a zero backlash assembly.



Pat. Pending

Features: Zero backlash • Maximum operating angle of 30° • Lightweight • Sealed-in lubrication.

Materials: Body—303 stainless steel • Balls—440 stainless steel • Special assemblies of non-magnetic balls available.

SINGLE JOINTS

Part No.	Bore	Body	Lgth.	Torque In. Oz.	Price 1-9 pcs.
SBS	SOLID	3/16	1-1/32	16	3.95
1BS	.0938	"	"	"	4.65
2BS	.125	"	"	"	"
3BS	.156	9/32	1-3/8	64	4.55
4BS	.1875	"	"	"	"
5BS	.2188	3/8	1-3/4	256	4.50
6BS	.250	"	"	"	"

DOUBLE JOINTS

DB1BS	.0938	3/16	1-1/2	4	9.30
DB2BS	.125	"	"	"	"
DB4BS	.1875	9/32	2	16	9.10
DB6BS	.250	3/8	2-1/2	64	9.00

TELESCOPING JOINTS

Available in the Double Joint sizes and with same Torque ratings.

LARGE JOINTS

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Div. General Thermodynamics Corp.
209 Concord Turnpike, Cambridge, Mass.

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Catalogs and Bulletins.....continued

(E-62) Belt Drives—Catalog, 12 pp. Contains design features, belt sizes, applications, dimensions and specifications. Raybestos-Manhattan, Inc, Passaic, NJ.

(E-63) High-speed Transmission Belt—Brochure, 6 pp. Describes belt designed for high speed service, belt life and elongation characteristics. Gives technical data on hp capacity, pulley diameters, belt length. The Russell Mfg Co, 400 E Main Street, Middletown, Conn.

(E-64) Speed Reducers—Catalog, 46 pp. Dimensions and specifications for gearheads and speed reducers for control applications. Special designs and sizes in all ratios up to and beyond 3,000,000:1 designed and manufactured in any quantity Also contains photographs, outline drawings and ratio chart. Bowmar Instrument Corp, 8000 Bluffton Road, PO Box 2835, Fort Wayne, Indiana.

(E-65) Servo Actuator—Bulletin, 4 pp. Describes rotary hydraulic pneumatic actuator, with typical applications, possible variations and application form. Parameters, Inc, 195 Herricks Rd, New Hyde Park, NY.

(E-66) Stamped Gears—Brochure, 8 pp. Photographs, dimenisons and facilities available for line of stamped gears from stock or made to order specifications. Winzeler Mfg & Tool Co, 7355 W Wilson, Chicago 31, Ill.

(E-67) Gear Components and Assemblies—Brochure, 26 pp. Describes pitch, sizes, production facilities and applications of gear combinations. Advance Gear & Machine Corp, 5851 Holmes Ave, Los Angeles 1, Calif.

(E-68) Gears—Brochure, 25 pp. Describes various lines of gears and component parts, production capacity, machines and facilities available. Also provides tables for diametrical and circular pitch formulas and others. Quaker City Gear Works, Inc, Bethayres, Pa.

(E-69) Clutches—Bulletin, 7 pp. Describes construction, operation and applications of standard clutches. Also dimensions, order form and photographs. Curtiss-Wright Corp, Marquette Div, 1145 Galewood Dr, Cleveland 10, Ohio.

(E-70) Roller Chain Flexible Couplings—Bulletin, 8 pp. Contains construction and design features, selection data, dimensions, weights, installation and maintenance information. Chain Belt Co, Milwaukee 1, Wis.

(E-71) Centrifugal Clutches—Catalog, 16 pp. Gives economics of operation, performance characteristics, selection chart, dimensions, hp ratings and installation instructions. Formsprag Co, 23601 Hoover Rd, Warren, Mich.

(E-72) Clutches—Catalog, 26 pp. Describes overrunning clutches with information on applications, typical mounting arrangements and dimensions. Formsprag Co, 23601 Hoover Rd, Warren, Mich.

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Uniform lift
into equipment
with
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WORM GEAR
JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

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New high efficiency... higher horsepower ratings

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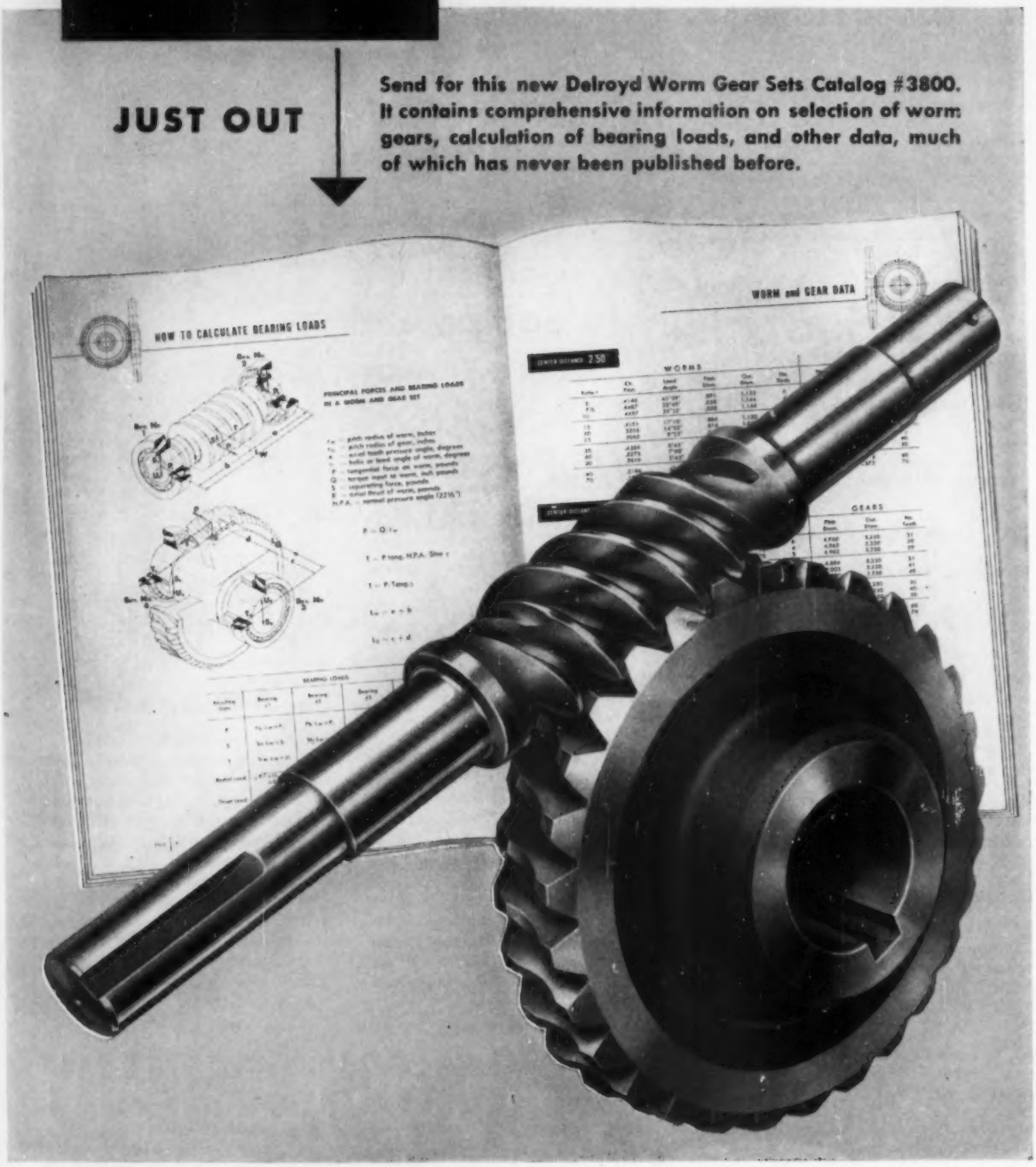
Send for this new Delroyd Worm Gear Sets Catalog #3800. It contains comprehensive information on selection of worm gears, calculation of bearing loads, and other data, much of which has never been published before.



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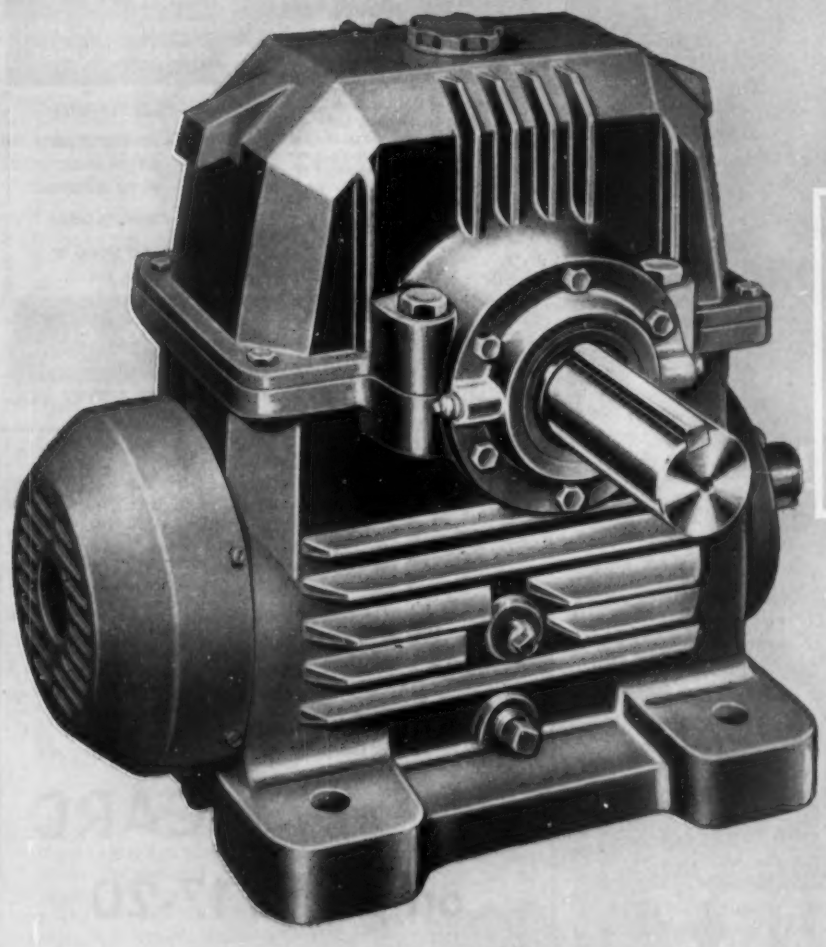
SPEED REDUCERS

De Laval Announces All New Line of Single Reduction Speed Reducers



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TYPE B
fan cooled
5" through 12"
center
distance
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Send for this new 32-page Bulletin 3805 today.

New Delroyd single reduction speed reducers are available in a wide range of sizes and horsepower ratings. These worm gear units include centrifugally cast gears and fan cooling, and carry *the new AGMA ratings.*

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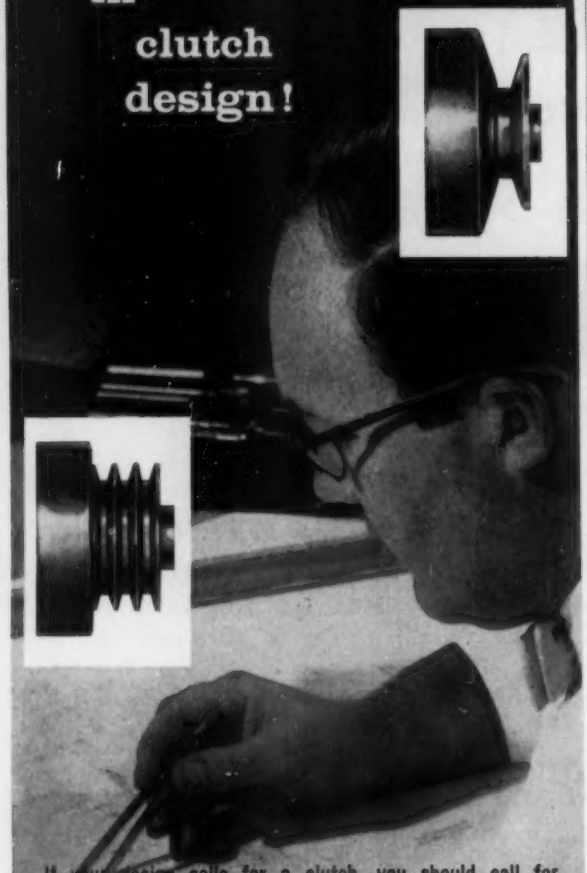
specialists in clutch design!



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Request catalog #BL-1 or see Sweet's Product Design File.

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MOLDED NYLON FIBERGLASS fhp GEAR REDUCERS and PULLEYS

Model SW-1 Gear Reducer

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additional product information
copies of catalogs & bulletins

Catalogs and Bulletins.....continued

(E-73) **Stamped Gears**—Catalog, 19 pp. Gives materials, finishes, size limitations, standard pressure angle, terms and formulas, tolerance and selection data. Fastex Div, Illinois Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(E-74) **Drive Belts**—Brochure, 4 pp. Describes sizes, parts, specifications and applications in addition to data on maintenance and materials. The Goodyear Tire & Rubber Co, Industrial Products Div, Akron 16, Ohio.

(E-75) **Production Machinery**—Brochure, 16 pp. Contains photographs of machines and facilities, equipment list, engineering and sales services which are available. Bedford Gear & Machine Products, Inc, 550 Krick Rd, Bedford, Ohio.

(E-76) **Gears**—Catalog, 36 pp. Includes descriptions, applications, manufacturing methods, dimensions, ratings, bearing loads and mounting methods. Spiroid Div, Illinois Tool Works, 2501 N Keeler Ave, Chicago 39, Ill.

(E-77) **Gears**—Catalog, 36 pp. Describes construction and applications; gives engineering information, test results, typical diameters and ordering information. Sier-Bath Gear & Pump Co, Inc, 9252 Hudson Blvd, North Bergen, NJ.

(E-78) **Steel Pulleys**—Brochure, 8 pp. Describes construction, gives engineering data, lists sizes for v-belt applications. Salem Stamping & Mfg Co, Inc, 634 W State St, Salem, Ohio.

(E-79) **Mechanical Differentials**—Catalog, 13 pp. Describes facilities and services for production of differentials, both stock and made to order models. Includes tracings of sample products and specifications. Arch Instrument Co, Inc, 101 Holmes St, Quincy, Mass.

(E-80) **Air Turbine Drive**—Bulletin, 4 pp. Describes high temperature and pressure operations, applications, construction, speed control characteristics and dimensions. Stratos, A Div of Fairchild Engine & Airplane Corp, Orinoco Dr, Bay Shore, NY.

(E-81) **Power Transmission Equipment**—Catalog, 135 pp. Gives specifications, charts, drawings and photographs of chain, couplings, clutches and others along with conversion table and selection information. The Morse Chain Co, A Borg-Warner Industry, S Aurora St, Ithaca, NY.

(E-82) **Variable-speed Transmissions**—Catalog, 24 pp. Gives information on typical applications and shows selection, rating, and dimensional data in tabular form. Lewellen Mfg Co, 1428 10th St, Columbus, Ind.

(E-83) **Power Transmission Devices**—Catalog, 7 pp. Drawings, specifications and hp ratings for speed reducers, pulleys, v-belts and accessories. Rampe Mfg Co, 14915 Woodworth Ave, Cleveland 10, Ohio.

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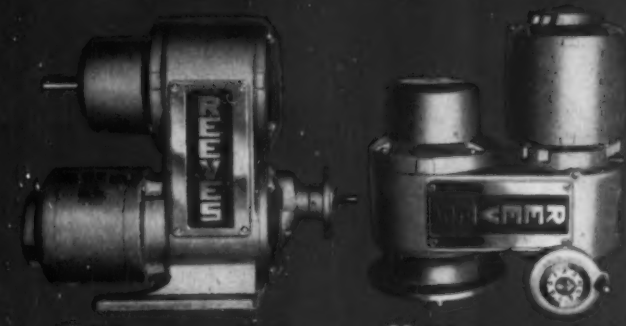
mean versatility in variable speed

101 *different standard assemblies* — 18 *different standard right angle assemblies*



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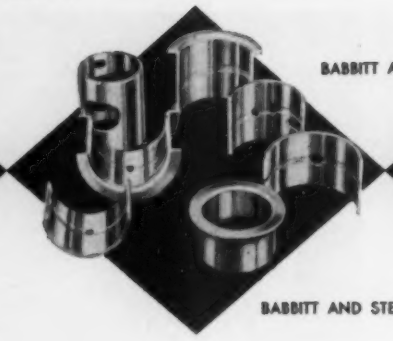

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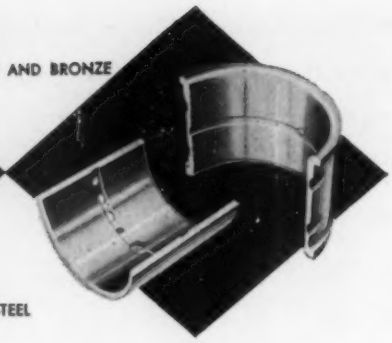

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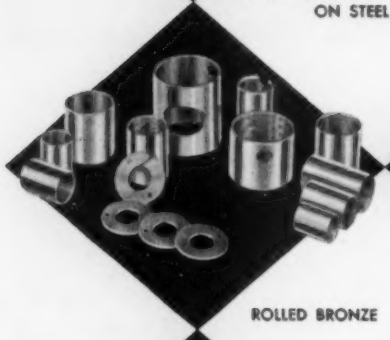

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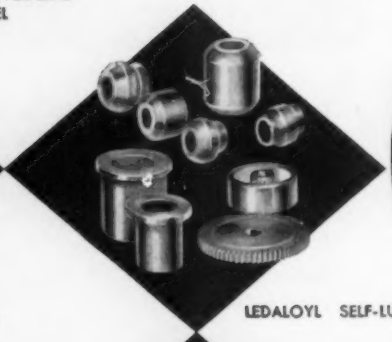

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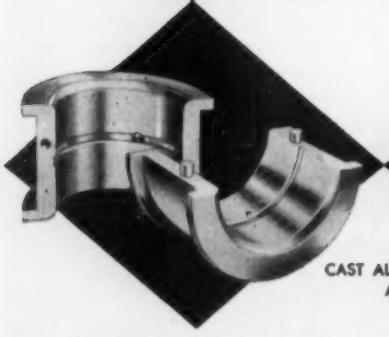

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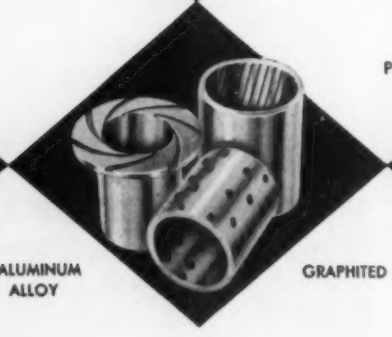

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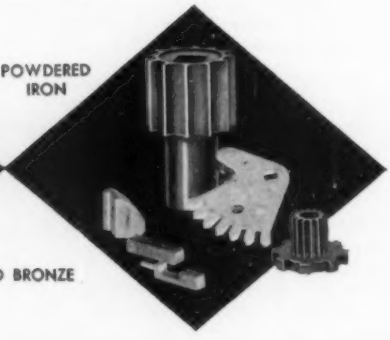

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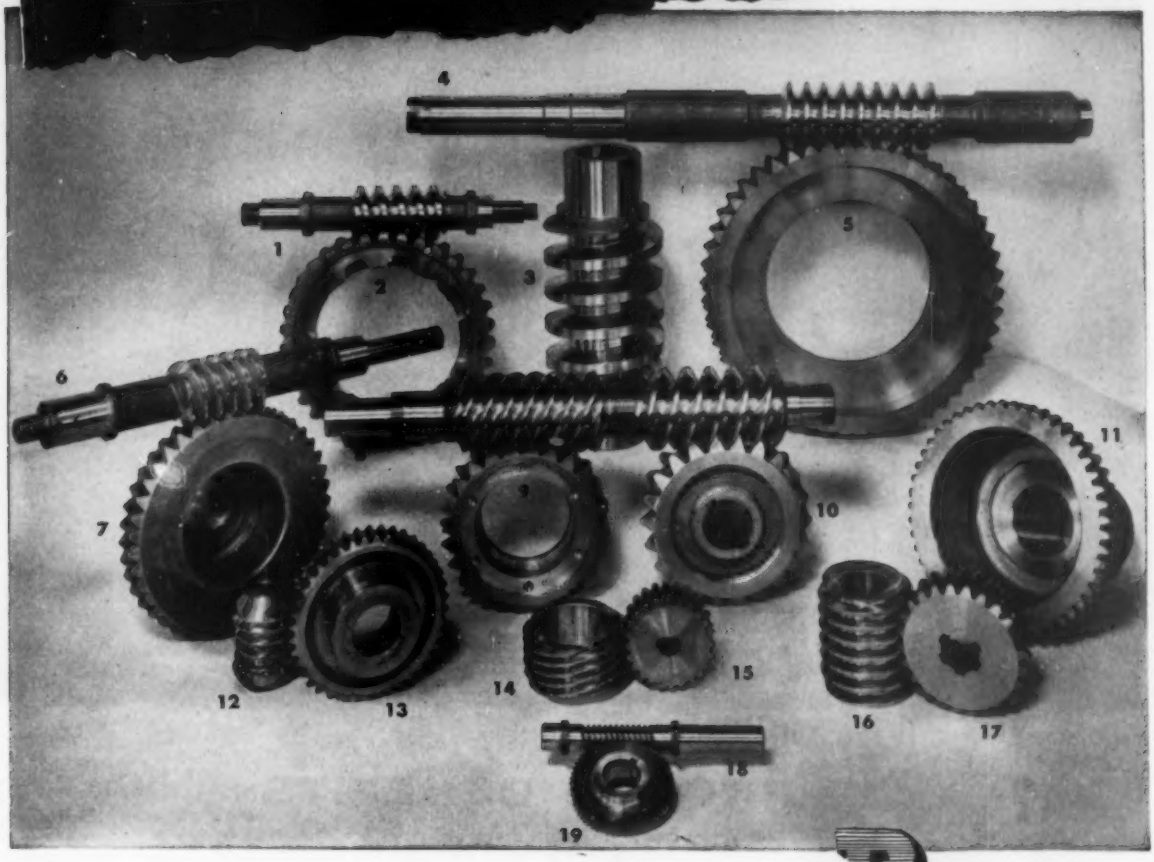
FOR ALL INDUSTRIAL APPLICATIONS

MADE TO YOUR SPECIFICATIONS!!



Be sure you have the exact gear you want — a QUALITY GEAR made to your particular requirements — checked 100% for tooth contact, center distance and Rockwell Hardness — at the right price too!!

BAUSH WORMS AND GEARS shown are a product of over 500 worm gear hobs we maintain at all times. Ranging from sets on 2⅛" center to 28" center, they cover up to and including 2" circular pitch.

YOUR SPECIFIC GEAR NEED CAN BE DESIGNED AROUND THESE HOBS ELIMINATING EXPENSIVE TOOLING AND DELAY.

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MACHINE TOOL CO.
SPRINGFIELD 7, MASSACHUSETTS

1 & 2 — Lift Truck
3 — Bending Roll Drive
4 & 5 — For Multiple Spindle Lathe
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8, 9 & 10 — 2-Speed Lathe Reduction
11 — Mixing Machine Gear
12 & 13 — Hourglass Type Worm & Wheel
14 & 15 — Lubrication Pump Drive
16 & 17 — Feed Drive-Automatic Machine
18 & 19 — Cutter Drive-Keywaying Machine

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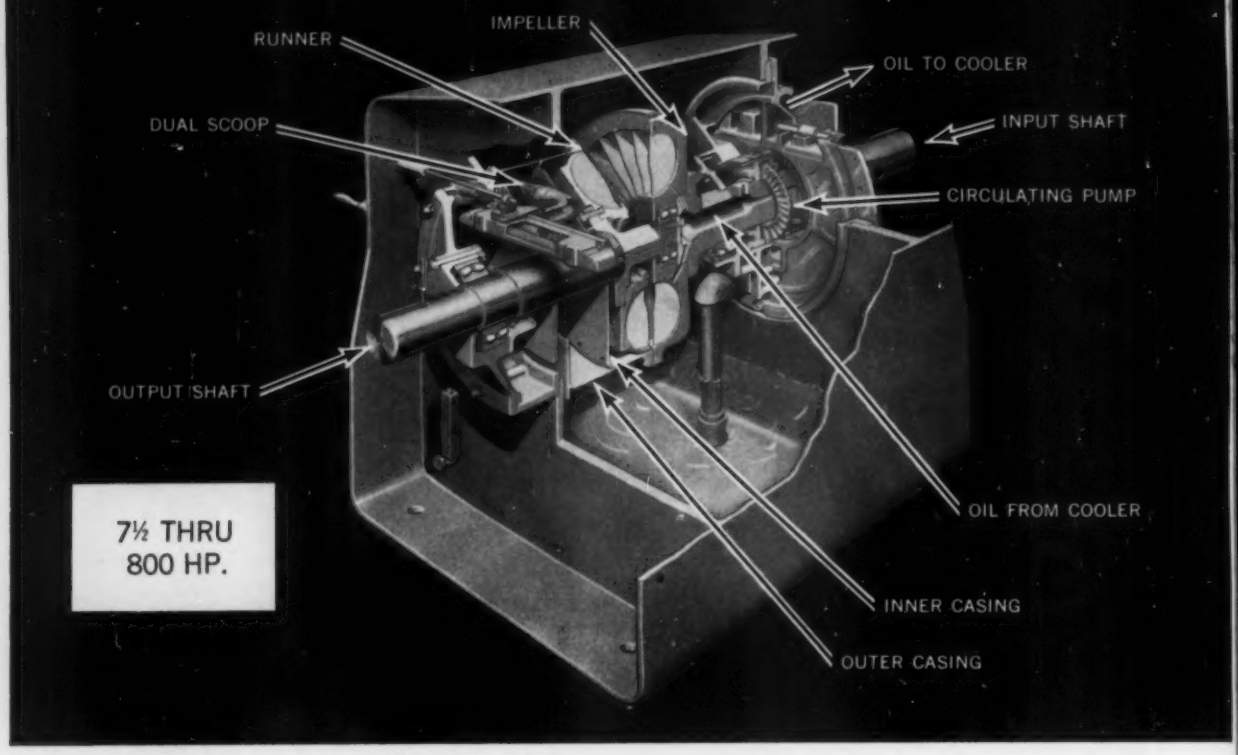


12 PROVED BENEFITS

1 No load starting – Gýrol Fluid Drive simplifies starting equipment because it permits the motor to reach operating speed before engaging the driven machine. Result: Motor can in many cases be selected for the running load—over-motoring for hard-to-start loads can usually be avoided.

2 Smooth, easy starting – Gýrol Fluid Drive provides stepless speed adjustments – accelerates loads without steps or bumps.

3 Controlled acceleration – Adjustable-speed Gýrol Fluid Drive allows fully controlled rate of acceleration – as slow or as rapid as required for specific processes, and to prevent overloading the motor.

4 Clutch and declutch action – Adjustable-speed Gýrol Fluid Drives have the ability to essentially declutch motors from their loads. When synchronous motors are used, the improvement in power factor can be gained at all times whether or not the driven machine is in operation.

5 Stepless, adjustable speed– Gýrol Fluid Drive's smooth, stepless speed control over the entire operating range makes it possible to run the driven machine at the speed required.

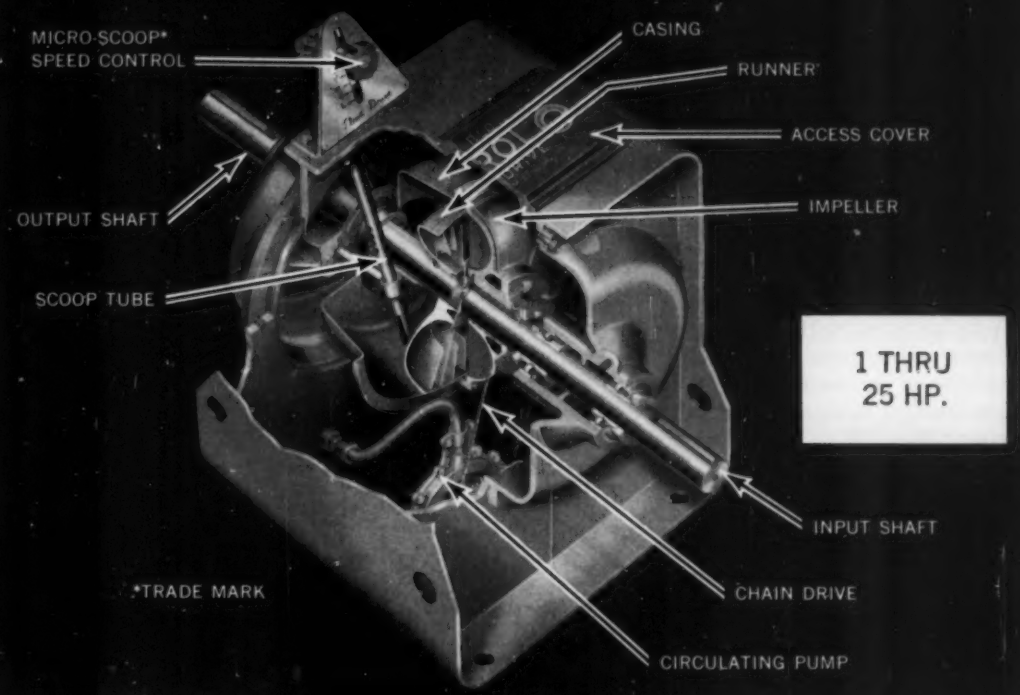
6 Isolation of torsionals–A Gýrol Fluid Drive transmits power through a cushion of oil with no mechanical connection. Shocks and torsional vibrations, originating from either driving or driven equipment, are isolated.

7 Limit against overload – Gýrol Fluid Drive has a definite maximum torque-transmitting capacity – governed by degree of oil-filling and input speed – which serves to protect both motor and driven machine against excessive overload.

8 Braking – Because Gýrol Fluid Drive can operate with input and output members rotating in different directions, dynamic braking for either intermittent or continuous duty is possible. Two proved applications: rapid deceleration of high WR^2 loads, and continual braking of paper unwinder rolls.

9 Minimum maintenance – Gýrol Fluid Drive has no mechanical connection between driving and driven shafts – no friction devices such as belts, clutches or sheaves to wear – no vacuum tubes, slip rings, brushes, or other electrical components to break or fail. Its nonwearing power-transmission medium – a vortex of oil – provides extra-long service life.

GÝROL® FLUID DRIVE

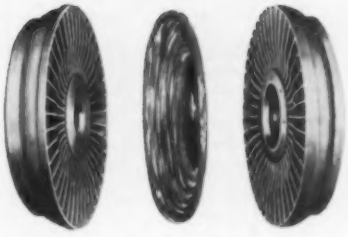


10 Wear or erosion reduction – On pumps, fans, or compressors, adjustable-speed Gýrol Fluid Drive permits lower average speeds than throttle-control with dampers or valves – greatly reduces erosion caused by abrasive particles in the air or liquid handled.

11 Reversible operation – All constant-speed and some adjustable-speed Gýrol Fluid Drives are completely reversible by reversing the motor – give identical performance in either direction of rotation.

12 Power savings – By providing stepless speed control without wasteful throttling, Gýrol Fluid Drive cuts horsepower consumption on centrifugal machines such as fans, compressors or pumps.

For complete technical information on Type VS Class 2 Gýrol Fluid Drives write for Bulletins A-119 and 9819, or call our local sales-engineering office. AMERICAN-STANDARD† INDUSTRIAL DIVISION, DETROIT 32, MICHIGAN. IN CANADA: AMERICAN-STANDARD PRODUCTS (CANADA) LTD., TORONTO, ONTARIO.



Using a vortex of oil to transmit power, Gýrol units provide simplicity of design, quietness, and flexibility offered by no other method of power transmission.

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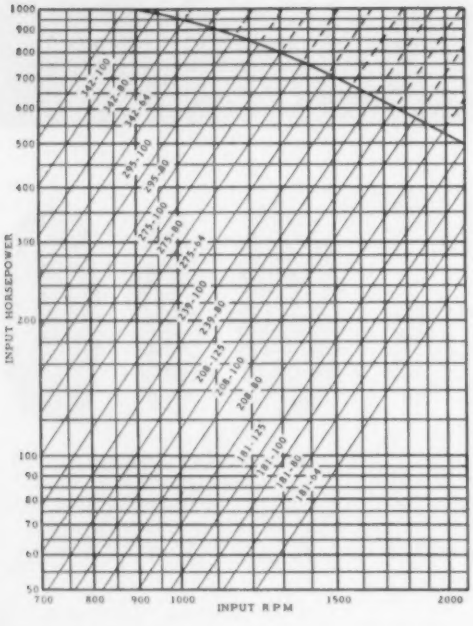
Plan now to DESIGN with National Torque Converters

for Internal Combustion Engine or Electric Motor Applications

Available with or without integral cooling systems

The six sizes and 17 hydraulic circuits available in the National Torque Converter line permit the exact matching of converter to internal combustion engines or electric motors from 100 to 1000 hp., and to job. Proper unit can be easily selected on chart below; find input rpm on horizontal scale, input HP on vertical scale. Diagonal area at point of intersection will show size and circuit needed. Curves showing torque-speed ratio for converter you select are available on request.

For more detailed technical information, ask for a copy of Bulletin 468.



Consider these National Torque Converter features

- Simplicity of Design for ease of installation, operation and maintenance
- Full Range of Circuit Sizes permits exact matching to internal combustion engines or electric motors of 100 to 1000 horsepower
- Top Performance enables prime movers to operate at its optimum speed . . . deliver maximum horsepower constantly
- Reproducible Efficiency assures uniform top performance on every job
- Faster Job Cycles means more loads per equipment per operator per day
- Unsurpassed Durability provides longer service life with minimum maintenance

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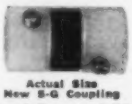
Gear-Grip . . .

The most revolutionary Flexible Coupling Design Development in a century!

Now available for sub-fractional, fractional and integral H. P.

Ability of rubber Flex-Elements to float between captive end fittings distributing load similar to universal joint action.



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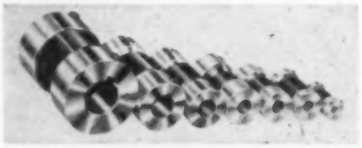
- Load Ranges—1/12 H.P. through 30 H.P.
- Shaft Sizes—⅛ through 1⅞.
- Specified exact length to design requirements per series.
- Prevention of end thrust among many other design advancements.*

Dyna-Line . . .

The finest flexible coupling in single unit construction—specifically designed for fractional H.P.



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- **Lengths varied to design specifications in each series.**
- **Load ranges—1/15 to 1½ H.P.**
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- **Lowest O.D. for highest torque capacity.**

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catalogs and bulletins.....continued

(E-84) Gears—Brochure, 4 pp. Specifications, applications, metallic and nonmetallic materials and engineering services for custom cut gears. Perkins Machine & Gear Co, Circuit Ave, W Springfield, Mass.

(E-85) Fluid Power Drives—Bulletin, 32 pp. Explains advantages, operation and characteristics of models, illustrating them with typical performance curves and block diagrams on various types of rotary applications. The Oilgear Co, 1560 W Pierce St, Milwaukee 4, Wisc.

(E-86) Variable Pitch Sheaves—Catalog, 13 pp. Operate on fixed centers, wide ratios using standard A, B and C-section belts. Gives selector chart, dimensions and drawings. Speed Selector Inc, PO Box 312, Chagrin Falls, Ohio.

(E-87) Variable-speed Drives and Differential Transmissions—Bulletin, 4 pp. Gives operations, applications, design and performance data for various types. Includes capacity charts, ranges and rpm information. Stratos, A Div of Fairchild Engine & Airplane Corp, Rt 109, W Babylon, NY.

(E-88) Drive and Conveying Chains—Brochure, 8 pp. Describes ASA standard and special roller, conveying, and drive chains. Lists sizes and sales information. Union Chain & Mfg Co, Sandusky, Ohio.

(E-89) Gear Reducers—Catalog, 15 pp. Contains mechanical specifications, prices, parts list and dimension drawings of various gear reducers for servo mechanisms, control equipment, computers and others. Link Aviation, Inc, Subsidiary of General Precision Equipment Corp, Binghamton, NY.

(E-90) Brake and Clutch Linings—Brochure, 4 pp. Describes wear characteristics, sizes, ratios and typical applications. World Bestos, New Castle, Ind.

(E-91) Variable-speed Drives—Brochure, 8 pp. Provides control arrangements for local, remote, reverse and dynamic braking operations, ¼ to 1½ hp. Offers circuit descriptions and schematics. Magnetic Amplifiers, Inc, 632 Tinton Ave, NY 55, NY.

(E-92) Low-inertia Clutch and Brake—Catalog, 4 pp. Describes operation, construction features and capacities of air-tube disc clutches and brakes. Includes photographs of typical applications and lists construction materials. Wichita Clutch Co, Wichita Falls, Texas.

(E-93) Adjustable-speed Drives—Bulletin, 6 pp. Construction, field-versatility and modifications of motorized mechanical drive are illustrated. Ratings from 1 to 30 hp. Louis Allis Co, 427 E Stewart St, Milwaukee, Wisc.

(E-94) Mechanical Clutches—Bulletin, 4 pp. Gives specifications and capacities of line of mechanical clutches. Includes construction materials, photographs and drawings. Wichita Clutch Co, Wichita Falls, Texas.

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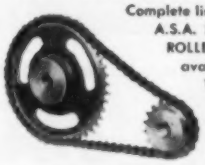

Complete line of stock bore, steel and cast iron single sprockets, cast iron hub sprockets and all steel split or solid hub sprockets available; also large selection of finished bore sprockets.

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The driven sprocket turns at a speed that is exactly proportionate to the speed of the driver sprocket. They operate without slippage or creep, and are unaffected by most atmospheric conditions.

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Acme Chain Drives deliver over 98% of the power furnished by the driving sprocket to the driven sprocket. There is practically no loss in the ratio of energy between driving and driven members. Compare this efficiency with other types of power transmissions.

ECONOMY

The initial cost of Acme Chain Drives is comparable and in many instances less than other types of power transmission and life expectancy is longer.

Power consumption is less when you use ACME ROLLER CHAINS. When necessary, repairs can be quickly effected with standard repair parts.

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"P" Series Power Air Brake . . . for heavy-duty automotive service. Unit mounted design offers compactness and simplifies installation. Open-type spider assures good internal ventilation and rapid cooling for longer lining life. Outstanding features for greater performance, lower maintenance.

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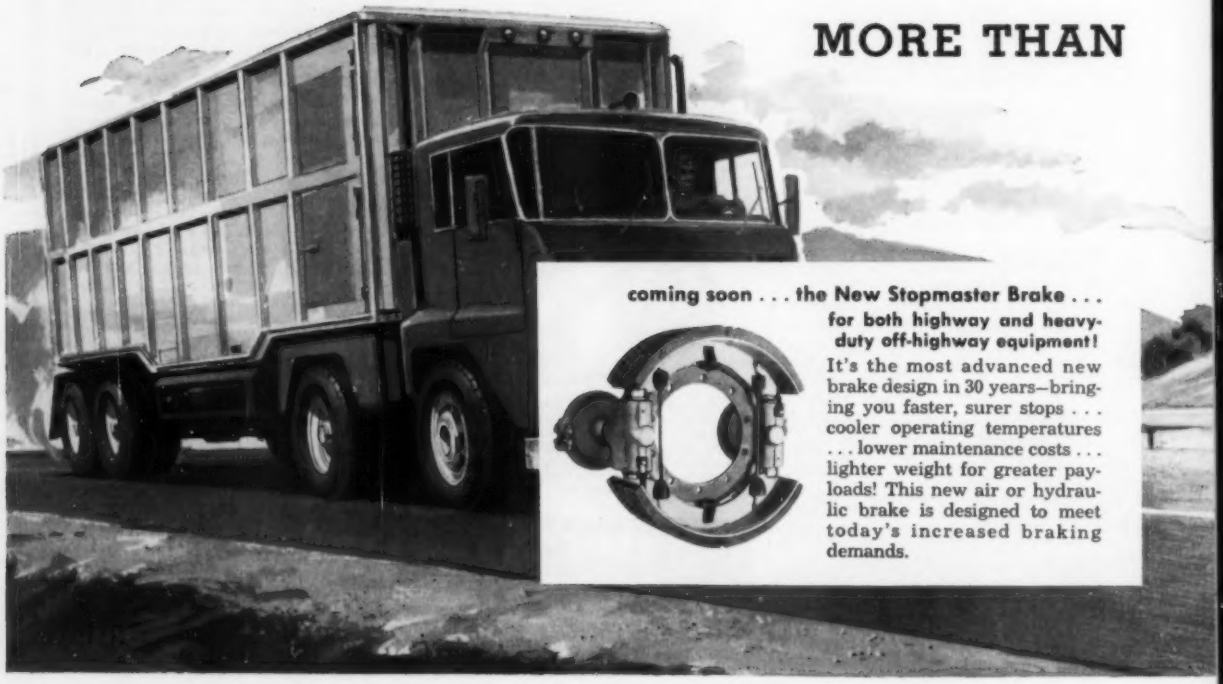

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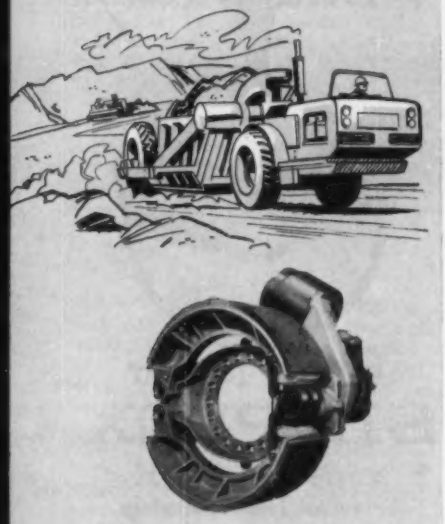
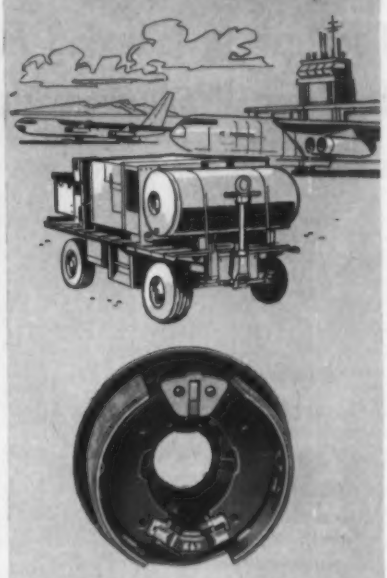


Heavy-Duty "P" Series Air Brake . . . offers better control, greater dependability, longer service for heavy-duty off-highway applications. Unit mounted design for compactness. Open-type spiders for lower operating temperatures and longer liner life. Wide range of capacities and sizes.

"DLM" Series Mechanical Brake... primarily a parking brake for trucks, buses, cranes and shovels, it also is ideal for use on farm equipment, hoists, lift trucks and other applications. Self-energizing two-shoe design. Only 8 parts with interchangeable shoes and springs. No lubrication required.



"DM" Duplex Mechanical Brake . . . for farm equipment, special-duty utility trailers, light-duty highway trailers and industrial machinery. Two identical shoes do an equal amount of work in either forward or reverse direction. Positive braking with immediate response. Simple design for low maintenance.

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Whatever the size or type of brake you require . . . whether it's for an industrial, agricultural, construction, or automotive application . . . Rockwell-Standard's complete line offers a brake that is specifically designed for your purpose.

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Every Rockwell-Standard brake design has been proven by rigid tests, both in the laboratory by trained technicians, and over thousands of miles of demanding road trials. It's just one more reason why you can be sure . . . your *best* brake is Rockwell-Standard!

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BRAKE DIVISION Ashtabula, Ohio

Backlash in Indexing Mechanisms for High Production Machinery

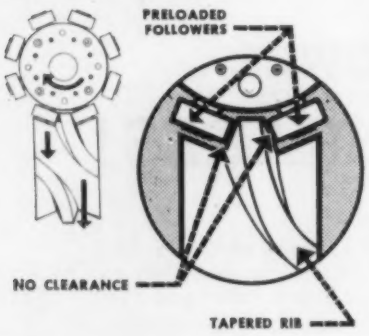
Backlash in indexing results in impact or shock loads that affect the efficiency of a machine and the quality of its product. Most indexing mechanisms have inherent characteristics that cause backlash and poor dynamic conditions and prevent the machine designer from taking full advantage of modern automatic feeds, tooling and methods that contribute so much to production economy.

Of the three principal indexing mechanisms, only one offers zero backlash and years of maintenance-free operation:

FERGUSON DRIVE

Continuously rotating cam includes a tapered rib, along which two preloaded bearing followers roll with no clearance between them and the rib. When the drive is in the rest, or dwell, position a straight portion of the rib locks the followers with *zero backlash* and an indexing accuracy of .001". Wear of the hardened cam is infinitesimal since it is subject to rolling friction only (many cams have been in use for more than 25 years). Followers are rated for a minimum of 8,000 hours precision operation at speeds up to 2,000 indexes a minute. If followers wear after this time, they can be replaced, thus renewing the drive for a like period.

FIG. 1 FERGUSON DRIVE



GENEVA DRIVE

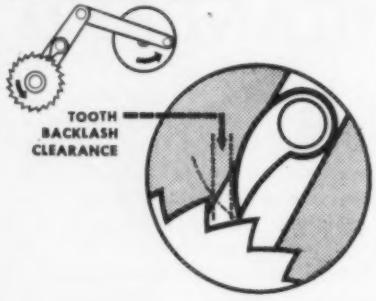
A geneva drive consists of a slotted wheel and a driver with a driving roller. Indexing occurs when the roller crashes into the slot, causing the wheel to move one increment. There must be clearance in the slot to allow passage of the roller. With clearance there must also be backlash. Impact loading, resulting from the inherent backlash, causes the slots to wear quickly and the backlash becomes progressively more severe. Operating speeds must be limited to contain the dynamic forces generated by backlash, even then, genevas require replacement with great frequency and downtime for maintenance is a major problem.

FIG. 2 GENEVA DRIVE

RATCHET & CRANK

Tooth clearance backlash causes the pawl to strike the ratchet teeth with considerable impact when indexing begins and vibratory forces are extreme. After mid stroke, the arm stops the pawl gradually but the wheel must be stopped by frictional braking or by positive means. Friction brakes allow over-travel and inaccuracy of index. They wear quickly and require excess downtime for maintenance. Because positive stopping is instantaneous, impact and rebound action of the wheel is tremendous. Neither method of stopping is satisfactory from the standpoint of low maintenance requirements or controlled dynamic conditions. Sustained high speed production is virtually impossible.

FIG. 3 RATCHET & CRANK



• SEND FOR CATALOG

Zero backlash is only one inherent advantage of the Ferguson Drive. Others are explained in an easy-to-use catalog containing load ratings and dimensions of many standard units, drawings and installation photos. There is a copy for every design engineer . . . Write **FERGUSON MACHINE CORPORATION, 7818 MAPLEWOOD INDUSTRIAL COURT, ST. LOUIS 17, MO.**

Announcing-

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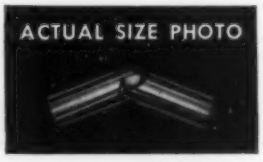
A 3/16" or larger O.D. Universal Joint featuring:

- **Minimum Static Torque Rating of 250 inch-ounces**
- **Non-magnetic stainless steel forks and bronze ball**
- **New simple 3-part design**
- **Minimum back lash**

Newest addition to the Curtis line is the Simplex, designed to fill the need for a small-size universal joint with a high Static Torque Rating. The Simplex is available in 3/16" and larger outside diameter. Made of non-magnetic material and incorporating a new design inherently strong in torque, the Simplex is particularly well adapted to electronic instrumentation.



SIMPLEX SPECIFICATIONS

Catalog Number	S3	S3B	S7	S7B
Static Torque Rating	250 Inch-Ozs.	250 Inch-Ozs.	200 Inch-Lbs.	200 Inch-Lbs.
O.D.	3/16"	3/16"	7/16"	7/16"
Bore	None	3/32" Dia. 5/16" Deep	None	7/32" Dia. 9/16" Deep
Total Length	1"	1"	2"	2"
Max. Angle of Operation	20°	20°	20°	20°

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POWER TRANSMISSION

catalogs and bulletins.....continued

(E-95) **Flexible Couplings**—Bulletin, 4 pp. Specifications, selection methods and service factors for bronze-bushed, rubber-cushioned type and dihedral gear types. Ajax Flexible Coupling Co, Inc, 72 Portage St, Westfield, NY.

(E-96) **Clutch-pulley Package**—Brochure, 6 pp. Describes electric clutch and ball bearing sheave unit for cycling of machine drives. Gives mounting instructions, dimensions, cutaway drawings and selection measures. Warner Electric Brake & Clutch Co, Industrial Products Div, Beloit, Wis.

(E-97) **Magnetic Clutches and Brakes**—Bulletin, 4 pp. Lists military, electrical and mechanical specifications. Charts, dimensions, sizes and modification data. Dynamic Instrument Corp, 59 New York Ave, Westbury, NY.

(E-98) **Variable Speed Drives**—Bulletin, 8 pp. Information about basic types of variable speed drives; includes modifications and cutaway drawings showing positive pulleys and remote control data. Sterling Electric Motors, Inc, 5401 Telegraph Rd, Los Angeles 22, Calif.

(E-99) **Magnetic Clutches and Brakes**—Bulletin, 4 pp. Provides specifications and operating data on multiple disc clutches and brakes; also describes spring engaged, magnetically released brakes. Fawick Airflex Div—Fawick Corp, 9919 Clinton Rd, Cleveland 11, Ohio.

(E-100) **Speed Reducers**—Catalog, 95 pp. Describes line of reducers, gear motors, worm and gear sets; provides lubrication, selection and ordering information in addition to AGMA ratings. The Morse Chain Co, A Borg-Warner Industry, S Aurora St, Ithaca, NY.

(E-101) **Clutches and Brakes**—Catalog, 28 pp. Standard line of miniature clutch and brake units. Giving installation data, torque, ratings, typical applications and minimum performance curves. Autotronics Inc, Box 208, Florissant, Mo.

(E-102) **Variable and Combination Pulleys**—Catalog, 26 pp. Tables and diagrams showing engineering information and typical applications. Lewellen Mfg Co, 1428 10th St, Columbus, Ind.

(E-103) **Gears**—Brochure, 4 pp. Cites examples of fine pitch gears, also table of gear tooth parts as recommended by AGMA. Beaver Gear Works, Inc, 1025 Parmele St, Rockford, Ill.

(E-104) **Belt Drives**—Catalog, 67 pp. Describes application range, bushings, hp capacity ratings and installation techniques. Gives selection procedure and ordering information. The Morse Chain Co, A Borg-Warner Industry, S Aurora St, Ithaca, NY.

(E-105) **Spur Gears**—Catalog, 7 pp. Lists tolerances and specifications for various master spur gears in stock. Invo Spline, Inc, PO Box 25, Hazel Park, Mich.

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HI . . . in capacity — will handle up to double the load.

HI . . . in versatility—More load with no increase in size or weight.

HI . . . in performance — Fin and fan cooled for greater capacity with less heat rise.

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HI-Line reducers are available in six new series ranging from 1.33" to 5.25" centerdistance. Standard models in each series include vertical with high or low base, and horizontal models with worm upper or lower.

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Manufacturers of gears and speed reducers - both stock and special

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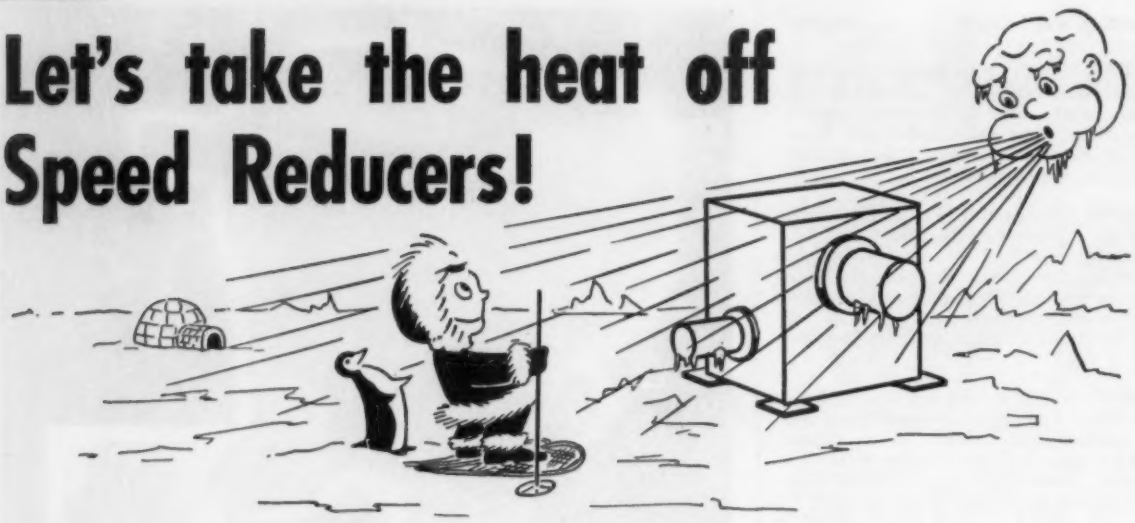
Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

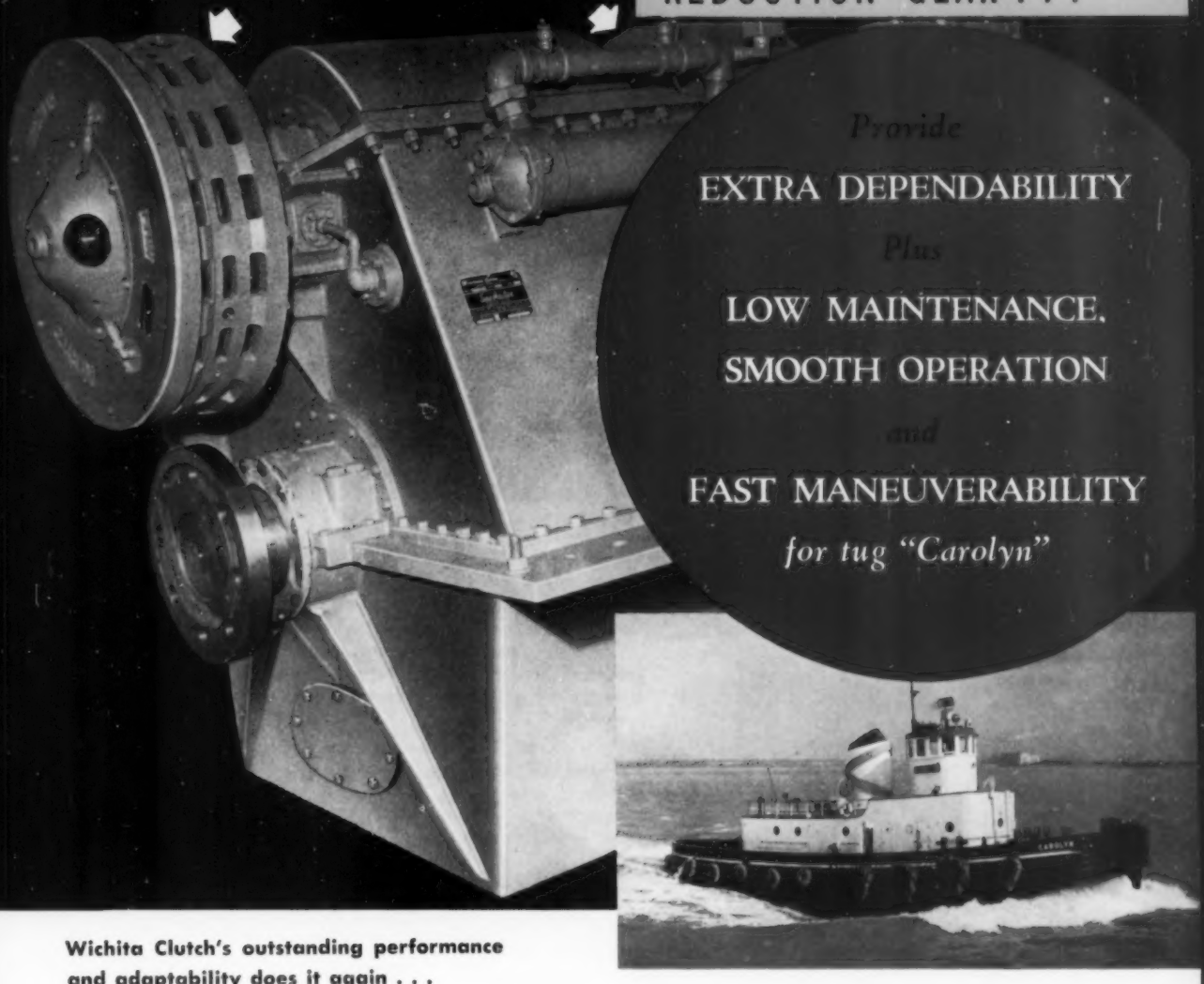
In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

WICHITA CLUTCHES . . . TEAM WITH NEW WESTERN SEA MASTER REVERSE AND REDUCTION GEAR . . .



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Combination of Wichita Air-Tube Disc Clutches and Western's new Sea Master Gear design raises the standards of marine operation by reducing maintenance to a minimum, and providing smooth operation and fast maneuverability.

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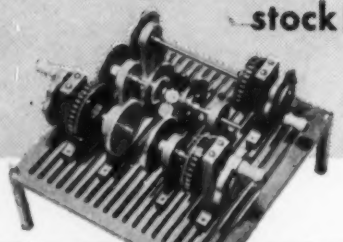

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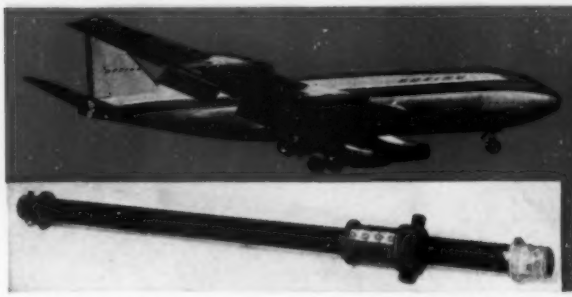
Beaver Ball Screws, Splines, Ways



Wing flaps of Boeing's monster 707 jet are actuated by Beaver ball screws. This is but one of more than 20 famous commercial and military aircraft that rely on Beaver, exclusively, for control of vital operating parts where precision, space, weight and power requirements are paramount design considerations.

This tape controlled skin mill, manufactured by Hypro Division of Giddings and Lewis Machine Tool Co., employs four Beaver Precision ball screws up to 16 feet long. They control vertical and horizontal positioning of cutting heads and swiveling of the work chuck.

Gain optimum positioning control with system stiffness—Reduce 'stixion' to a minimum

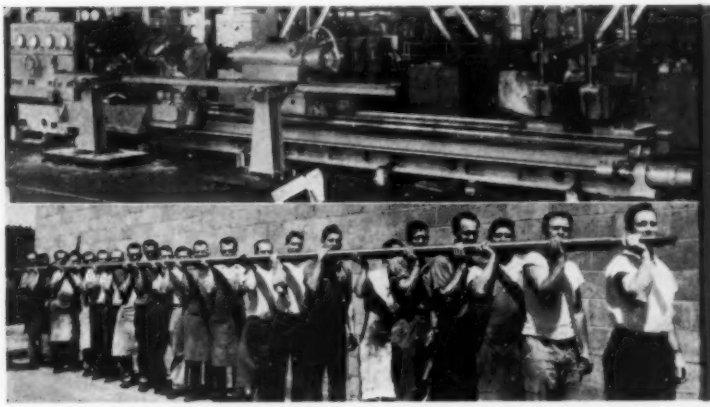
In a Beaver actuating device which employs rolling balls to eliminate friction encountered with the acme screw, engineers find many accompanying advantages. By preloading, a degree of system stiffness is accomplished to control motion with greater precision than ever before possible, while power and space requirements are reduced along with weight. Static friction closely approaches kinetic friction. Back-lash and surge are eliminated. Beaver ball screws rate better than 90% efficient.

Beaver occupies a dominant position in the area of ball screw application engineering. The company's facilities are planned not only for furnishing production requirements, but for assisting manufacturers through experimental and prototype stages. Size and quantity are no factor.

CONTRIBUTES TO NUMERICAL CONTROL EFFICIENCY

Beaver has made major contributions to the effectiveness of tape and card control of machine tools. In a minimum of space, with a minimum of power, Beaver ball screws provide precise control and repeatability in table feeds and other horizontal and vertical axes. As a result they are specified exclusively by an impressive list of leading machine tool manufacturers.

Our engineers are available to discuss your design problems with you.



The table of this giant steel mill roll lathe, built by E. W. Bliss Co. and designed by their Mackintosh-Hemphill Division, is actuated by a Beaver Precision ball screw that is probably the longest ever built, approximately 40 feet. The nut is preloaded to eliminate back-lash and increase system stiffness. The cross slide of this same machine is also controlled by a Beaver ball screw.

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CLAWSON, MICH.

E POWER TRANSMISSION

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Universal Joints

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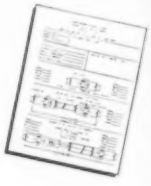
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TWIN DISC CLUTCH COMPANY
Racine, Wisconsin

Please send me a copy of your new Bulletin No. 314 covering specifications on all Twin Disc Friction and Fluid Drives.

Name_____

Title_____

Company_____

Street_____

City_____ State_____

DODGE of Mishawaka, Ind.

DODGE MANUFACTURING CORPORATION

1200 Union Street, Mishawaka, Indiana

Specialists in Power Transmission Machinery for 80 Years

DODGE DYNA-V DRIVES . . . Save Space, Weight, Money!

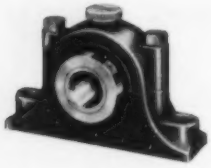
An entirely new line of V-belt drives that transmit more horsepower, require less space, generally *cost less*—and handle up to three times as much horsepower in a given space. Narrower grooves, to match stronger, narrower Dyna-V belts, greatly reduce the width and weight of Dyna-V sheaves. Dyna-V belts are built with a crowned top which keeps the Flex-Bonded cords in alignment so that they share equally in carrying the load. Dyna-V sheaves have Taper-Lock bushings for quick, sure mounting—interchangeable in other Taper-Lock products. Dyna-V drives are stocked in two belt widths for capacities to 200 hp. Drives up to 1500 hp furnished on order.

DODGE TAPER-LOCK ROLLER CHAIN DRIVES . . . No Reboring! No Waiting!

All to ASA Standards. Dodge Taper-Lock sprockets are *modern*—save time and money. Single Strand Chain and Sprockets—Nos. 35 to 160. Sprockets to 112 teeth. Double Strand Chain and Sprockets—Nos. 35-2 to 80-2. Sprockets to 112 teeth. Double Pitch Chain and Sprockets—Transmission Series (Nos. 2040 to 2080) and Conveyor Series (Nos. C2040 to C2100). Sprockets to 112 teeth, with *special double pitch design* in 17, 19, 21, 23, 25 and 35 teeth sizes—sizes in which special spacing is required for perfect tooth action. Conveyor Series, Large Roller—Nos. C2042 to C2102. Standard Attachments. Steel Plate Type A Sprockets—Nos. 35 to 120.

DODGE FLEXIDYNE "DRY FLUID" DRIVES

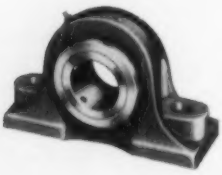
Flexidyne is the surest way to start loads *smoothly*—to protect against damaging overload—*without any sacrifice of efficiency at full load!* It is a "dry fluid" drive that uses heat-treated steel shot as a "flow charge." Initial slippage is momentary. Housing and rotor become locked together by the flow charge and full load is achieved without slip and at 100% efficiency. Flexidyne's "soft start" eliminates the need for oversize or high torque motors. Equipment lasts longer. And big savings are possible in the processing of materials that readily break. Eight drives, ten couplings—fractional to 1000 hp—available from stock. Larger sizes furnished to order.



DODGE PILLOW BLOCKS WITH TIMKEN BEARINGS

America's *quality* pillow blocks—for extreme dependability of service, from general power transmission needs to industry's heaviest, toughest jobs. Genuine Timken Tapered Roller Bearings give these pillow blocks their high radial and thrust load carrying capacities. Rugged. Precision built. Self-aligning. Easy to mount and demount. Assembled, lubricated, adjusted and *sealed* at the factory—ready for the shaft and for years of trouble-free, economical performance.

Available from stock in five types—Type E, Double-Interlock, Type C, Special Duty and All-Steel. Shaft sizes, 1 3/8" to 10". Expansion and non-expansion.



DODGE BALL BEARING PILLOW BLOCKS—SC AND SCM

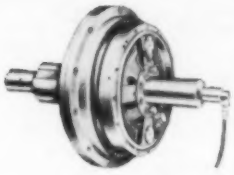
The SC and SCM ball bearing pillow blocks have been developed to provide—at low cost—high quality, anti-friction bearing service for small shafts and moderate loads.

They are assembled, lubricated and *sealed* at the factory . . . ready for the shaft. Precision built throughout, they feature deep groove ball bearings for high radial and thrust capacity. Long inner race distributes load over greater shaft area. Metal backed synthetic seals that can't blow. Rugged one-piece semisteel outer housing. Fully self-aligning.

SC pillow blocks for normal duty on 1/2" to 2 7/16" shafts. SCM pillow blocks for medium duty on 1 7/16" to 3 1/2" shafts.

DODGE TORQUE-ARM SPEED REDUCERS . . . Quality, High Efficiency!

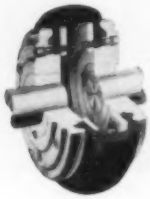
America's most complete line of shaft mounted speed reducers—55 models. Capacities from 1 to 200 hp. Output speeds from 10 to 378 rpm. Single or double reduction. Ratios of 5:1, 15:1 and 25:1. Speed ratios up to 150:1 with correct selection of speed reducer and V-belt drive. Rugged, corrosion-resistant, semisteel housings. Rigid, widely spaced seats for anti-friction bearings. Heat treated, helical steel gears. Modern double-lip seals. Vertical or horizontal mounting. Reducer locks to shaft on *both* sides of housing. Holes in the output hub provide simple removal with puller. Overload release and built-in backstop are optional.



DODGE AIR-GRIP CLUTCHES . . . Instant Response!

Maximum torque capacity in minimum space is provided by these fast, responsive air clutches. Full sensitivity of control from "inching" to complete engagement. Operate at air pressures up to 140 psi—with minimum air volume. Quick-release air valves built into the clutch are available as optional equipment for operations requiring instant disengagement. Air seal disc is located at the end farthest from the pressure plates, which generate the heat inherent in clutch action. Internally ventilated for cooler operation and longer life.

Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.



DODGE PARA-FLEX FLEXIBLE CUSHION COUPLING

The "4-way flex" of this unique coupling automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three*. It cushions the stresses of shock loads. And it absorbs torsional vibration — reducing noise and protecting machinery from vibration's destructive forces. Here is a new type of performance made possible by the development of a tire-like flexing element.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings. The flexible member can be replaced *without moving either the driver or driven machine*. Available in capacities up to 825 hp.

DODGE TAPER-LOCK COUPLINGS . . . Chain, Rigid, Flexible

Ready for the shaft without reboring or machining. Bushings are interchangeable in Taper-Lock products.

Dodge Flexible Disc Couplings are available from stock in shaft sizes from ½″ to 3″. Dodge Rigid Couplings from ½″ to 6″. Dodge Taper-Lock Chain Couplings from ½″ to 3″. Dodge Taper-Lock Chain Couplings permit sufficient movement between hubs to accommodate common minor angular and parallel shaft misalignment. The double width chain and extra teeth give additional bearing area for higher horsepower ratings and longer life. Available with covers for safety, dirt protection and lubrication.

DODGE TAPER-LOCK STEEL CONVEYOR PULLEYS

The steel rims, discs and hubs of these modern conveyor pulleys are fused together into jointless drum construction to give (1) maximum strength with a minimum of weight, (2) exclusion of dirt, water and steam, (3) exceptional shock resistance.

Submerged arc process welds contribute to the ultimate in strength. Dodge patented back-up bar makes possible rim welds of *full* rim thickness. Taper-Lock bushings provide the equivalent of shrunk-on fit—there's no "walking" on the shaft. Mounting and demounting are simple. Alignment is easy.

Diameters from 6″ to 96″—all widths. Standard or special rubber lagging available.

CALL THE TRANSMISSIONEER — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.

And Now
. . . in answer to industry's mandate

The Clutch with the Original Stationary Air Housing

Stationaire BY CONWAY

- **Middle-Shaft Mounting Accommodation**
- **No Shaft Drilling**
- **Traditional Conway Quality**

Gear Drive with outflange Adapter

POWER *by Conway* THROUGH AIR

Lug Drive Mechanism

Pat. Applied for U.S.A. and Canada

"Just what we have been waiting for" is all we've been hearing. And as usual, Conway has come up with the right answer. Larger units designed specifically for your job. ALL with Conway's traditional conception of high quality at prices within reason.

The World's Most Respected Name in Industrial Clutches for over a Half-Century

WRITE FOR CATALOG 858

MODEL	DRIVE TYPE	NOMINAL WORKING TORQUE AT 60 PSI IN LBS.	DESIGN TORQUE AT 60 PSI IN LBS.
858-3	Lug	210	315
858-5	Lug	1260	1890
858-8	Gear	3780	6300
858-12	Gear	11340	18900
858-14	Gear	15120	22680

★6 drives available: Inflange or Outflange Adapter, bronze bushed or ball-bearing sleeve, bronze or ball-bearing pilot coupling. Additional models to be introduced soon.

Note: Torque can be increased on all models either by incorporation of sintered bronze drive discs or by increase of air pressure. Please consult the Conway engineers if this is desired.

The CONWAY CLUTCH COMPANY
2760 COLERAIN AVE. CINCINNATI 25, OHIO

"All Product Ad" — used in catalogs and directories.

FALK

...a good name in industry

QUALITY GEAR DRIVES and FLEXIBLE SHAFT COUPLINGS

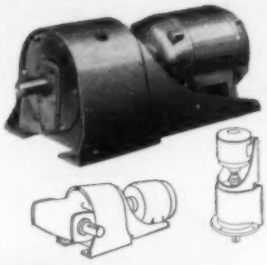
THE FALK CORPORATION, MILWAUKEE 1, WIS. *Representatives and Distributors in many principal cities.*

● The helical and spiral bevel gears in Falk gear drives assure maximum mechanical efficiency attainable—98½% per gear mesh under full load.

ALL-MOTOR MOTOREDUCERS *up to 75 hp.*

All-steel units for use with any NEMA foot-mounted motors within rated capacities of the gear drives. Standard output speeds from 1.2 to 780 rpm (with 1750 rpm motors); as low as .032 rpm in semi-standard designs. Also Integral units, from 1 to 40 hp.

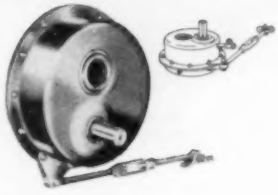
Ask for Bulletin 3100.



SHAFT MOUNTED DRIVES *up to 50 hp.*

All-steel units, horizontal or vertical. Output speeds between 420 and 5 rpm. Maximum torque rating at low speed shaft: 41,000 lb-in. Consult Factory for higher capacities and for flange mount and screw conveyor drives.

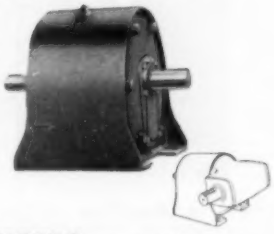
Ask for Bulletin 7100.



SMALL SPEED REDUCERS *up to 138 hp.*

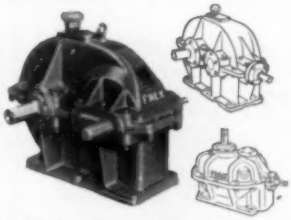
Concentric Shaft Ratios from 1.49:1 to 970:1. Max. torque at low speed shaft: 80,000 lb-in. **Right Angle** Ratios from 5:1 to 1460:1. Max. torque at low speed shaft: 73,000 lb-in.

Ask for Bulletin 1105.



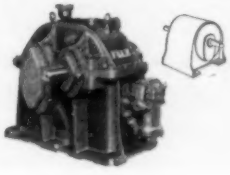
LARGE SPEED REDUCERS *up to 3500 hp.*

Parallel Shaft up to 3500 hp. Ratio range: from 2:1 to 300:1. Max. catalog torque at low speed shaft: 1,950,000 lb-in. Bulletin 1110B. **Right Angle Horizontal** up to 1000 hp. Ratio range from 1.5 to 515:1. Max. catalog torque at low speed shaft: 569,000 lb-in. Bulletin 2105B. **Right Angle Vertical** up to 760 hp. Ratio range from 6:1 to 430:1. Max. catalog torque at low speed shaft: 714,000 lb-in. Shafts up or down. Bulletin 2110B.



HIGH SPEED DRIVES ... *reducers or increasers.*

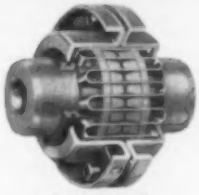
Parallel Shaft Cataloged units up to 5,000 hp or 10,000 rpm. Ratios up to 40:1. Bulletin 510' **Concentric Shaft** Cataloged units up to 225 hp or 4500 rpm. Ratios up to 25:1. Bulletin 1106.



STEELFLEX COUPLINGS *protect connected machines.*

Hp range: ½ through 72,000 hp at 100 rpm. Exclusive grid-groove design cushions shock loads, accommodates reasonable degrees of shaft misalignment. Basic Type F for 9 out of 10 industrial applications, horizontal or vertical.

Ask for Bulletin 4100.



Basic Type F

AIRFLEX COUPLINGS

Designed for mounting shaft-to-shaft, shaft-to-flywheel, or shaft-to-flange.

15 sizes covering a range from 5 through 2880 hp at 100 rpm. Ideal for applications which have irregular torque characteristics in driving or driven machines (internal combustion engines, reciprocating compressors, etc.).

Ask for Bulletin 8100.

SINGLE HELICAL and HERRINGBONE GEARS

Exclusive Falk extra-depth, high pressure angle gear teeth provide greater strength and protection against abrasion. AGMA ratings.

Diameters up to 18 ft.

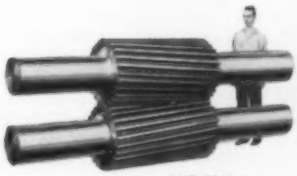
Face widths up to 6 ft.

Diametral Pitch: ¾ to 6 dp.

Hub or ring gears in solid or split designs.

Hub Gears

Ask for Engineering Reports 6170 and 6171



Mill Pinions

Special GEAR DRIVES for any application.

Special HIGH SPEED DRIVES... over 50,000 rpm.

Marine PROPULSION DRIVES for turbine and diesel.

FALK, ALL-MOTOR, and STEELFLEX are registered trademarks.

WRITE 271 ON READER SERVICE CARD

SMART DESIGN ENGINEERS SUBMIT THEIR

CLUTCH AND BRAKE

PROBLEMS TO US

They do it every day . . . because they save time, engineering costs, and design headaches by using our PROVEN, standardized clutch and brake units.

Shown here are the basic types . . . including the Industry's most successful ELECTRIC Clutches and Brakes . . . available from stock in a full range of sizes, and ready to go to work in your equipment with assured performance.

Equally valuable is the advice and practical help on special problems available to you by calling our experienced engineering department. It usually pays to "TALK MAXITORQ" first.

SERIES 8000 ELECTRIC CLUTCHES AND BRAKES

PROVED design, Floating Disc action is fast and positive, with no heating or drag in neutral. Compact, simple, with few moving parts. For WET or DRY operation: Electrical operating unit DOES NOT REVOLVE; no brushes or slip rings. Uses easily replaced standard Disc-Pac. Requires no adjustment. Wide range of standard sizes, single and double types. All sizes rated 80 watts, operate on 110 V.A.C., rectified to 90 V.D.C. Other voltages on special order.

SERIES 9000 ELECTRIC CLUTCHES AND BRAKES

Operation is induced entirely by magnetic flux which provides fast response. There are no brushes, slip rings, stressed parts or wiring problems. Flexibility of control, compact design, drag-free neutral, ease of installation, suggest a wide range of applications from simple machines to punched tape or other automated equipment. They operate on 90 V.D.C. rectified from 110 V.A.C. Other voltages on special order.

STANDARD FLOATING DISC CLUTCHES AND BRAKES

MAXITORQ offers you PROVED performance in every type of service with the following important advantages: compact design with few and sturdy parts . . . floating neutral with no heating or drag . . . positive engagement or release with light pressure . . . manual assembly and adjustment . . . full range of sizes and types . . . supplied as a completely assembled and easily installed unit.

OVERLOAD RELEASE CLUTCHES

One of the simplest and most efficient methods of providing a DEPENDABLE and easily adjusted overload release feature combined with a clutch. Incorporates all the advantages of MAXITORQ Floating Disc design plus automatic and complete release upon overload. Proved in service. Available in a wide range of sizes.

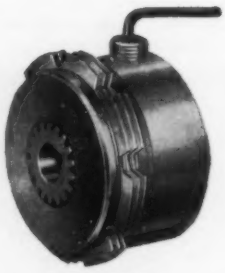
DISC-PAC

The "heart" of the SERVICE-PROVED Maxitorq Floating Disc Clutch in a compact, assembled unit for those who wish to design and build their own clutch mechanisms. Supplied as complete units ready for use in 8 diameters 2" to 8", up to 800 ft. lbs. capacity. Also useful as a multiple disc brake or torque limiting device.

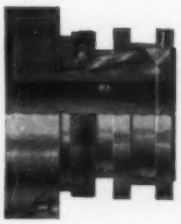
JOHNSON SINGLE DISC CLUTCHES

The modern, low cost, dependable clutch for light machinery drives to 6 h.p. Smooth, positive, long service. No matter what your clutch needs, discuss them FIRST with our engineers.

Series 8000 Electric Clutch



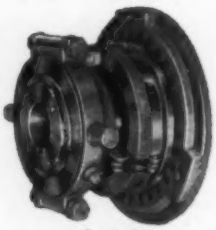
Series 9000 Electric Clutch



Standard Clutch

Overload Release Clutch

Disc Pac



Single Disc Clutch

Write Dept. PD for details on any of the above products and specify product by title.

LET'S TALK **Maxitorq**

THE CARLYLE JOHNSON MACHINE COMPANY

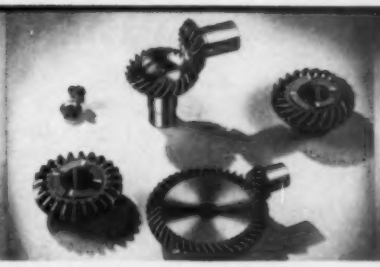
Manchester, Connecticut

2CJ59

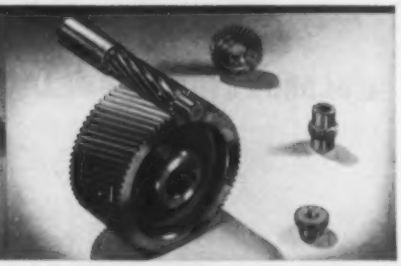
FRACTIONAL HORSEPOWER GEARING

43 Years of Specializing in Small Gearing!

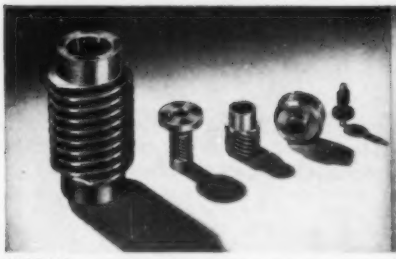
SPURS..from Spur Gears made from punched blanks to ultra precision cut. Applications include appliances, sewing machines, office machines, instruments.



SPIRAL BEVELS..Gears and Pinions made from alloy steels and hardened. Also, straight and zerol type teeth. Used in outboard motors, portable tools, lawn mowers and cameras.



HELICALS..and Spiral Gears are made of any material . . hardened and polished if required. Used in speed reducers, power tools, diesel engine fuel pump systems, etc.



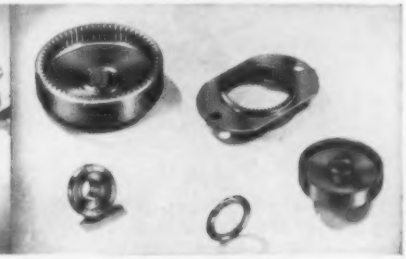
WORMS..complete facilities for milling, hobbing, grinding and super finish by an *exclusive* G.S. generate-polish. Typical uses: speed reducers, business machines, coin operated phonographs, fans, clippers, military equipment.

WORM GEARS..Laminated Plastic, Bronze, Nylon, Cast Iron, or Steel. Cut in curved and straight face. G.S. *patented grooves* for quietness. Used in valve seat grinders, food mixers, meat slicers, speed reducers, automatic phonos.

ARMATURE SHAFTS..Worms, Spur and Spiral Pinions, as well as Spiral Bevel Pinions cut integral with shafts. Diameters ⅛" and up. Used in floor polishers, fans, portable tools, etc. Gear sections hardened as needed.

UNUSUAL FORMS..Clutches, Sprockets, Cams, Segments, Lead Screws, Adjusting Worms. Mass manufactured for chain saws, outboard motors, check protectors, marine steering, telephone answering devices.

SPECIAL COMPONENTS..high precision parts for military and aircraft applications. Serrations, Splines, and Milling are held to close limits with precise tooth alignment.



INTERNALS..cut to exacting specifications up to 6" pitch diameters. Typical applications: air operated hoists, floor machines, radio equipment, navigating instruments.

G.S. MAKES YOUR SMALL GEARING WITH CUSTOM PRECISION, IN PRODUCTION RUNS...AT PRACTICAL COSTS

Whether your needs are numbered in the hundreds or the thousands . . . for any form of Fine or Intermediate Pitch Gearing . . . unmatched G.S. UNIFORMITY gives you greatest freedom from rejects, smoothest assembly, best field performance you'll ever find! G.S. standards are high—and they're backed by the most efficient machinery to be had, first-class design and production engineering, quality control systems which aim at perfection. If you need production runs of Small Gearing from 8 to 120 dp., from ⅛" to 8" diam., send drawings, specifications or a complete description of your project for suggestions, ideas and cost estimates without obligation to you.

SEND FOR FREE *Small Gearing Guide. It describes many types and applications as well as the greatly enlarged plant. Also contains useful charts. Please ask for your copy on company letterhead.*

GEAR
Specialties, Inc.
2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

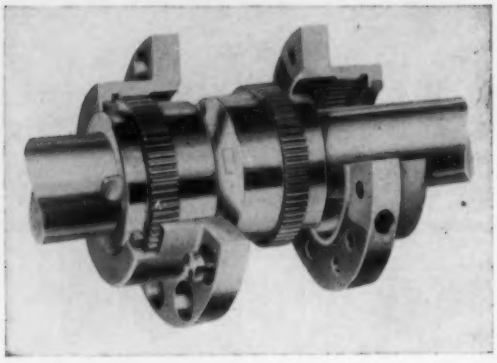
WRITE 273 ON READER SERVICE CARD 273

POWER TRANSMISSION

WALDRON POWER LINK COUPLINGS

Manufacturers of Gear and Pin Type Couplings for more than 40 years.

WALDRON STANDARD GEAR COUPLING



For Strength—

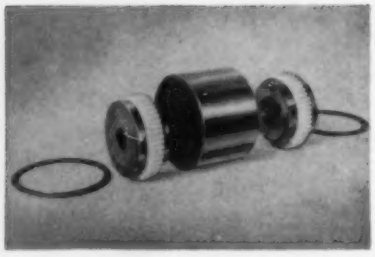
Hubs and cover sleeves for sizes 1¼A through 7A are machined from tough steel forgings. Hubs are keyed to the shafts. The two one-piece cover sleeves function as a single, rigid unit serving as a floating connecting link between the hubs. High strength of forgings makes possible a very compact coupling with low rotating inertia.

For Reliability—

There are no flexible parts to bend or break and the coupling is dust, moisture, and oil tight. Patented Walflex seal is at the lowest possible diameter where centrifugal force is least. Clearance between teeth in hubs and sleeve is engineered so that an oil wedge always separates them, taking the wear.

For Services—

Assembled rough bore couplings available for prompt delivery from Waldron Factory. Finish bored standard couplings shipped to meet customers' schedules.



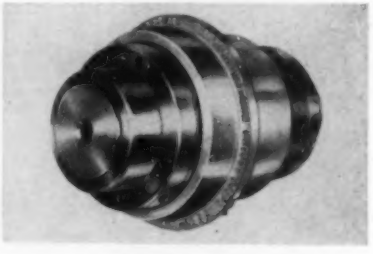
Series M

The new 162 M has unique features for users of gear couplings. Fitted with removable taperlock bushings, injection molded, stress relieved nylon gears, the 162 M needs no lubrication. Hubs machined from bar stock and steel sleeve complete a versatile new gear coupling. Shaft sizes from ⅝" to 1½" available at the present time, other sizes to come.

In All Popular Types and Sizes

Standard
Spacer
Oil Collector
Mill Motor
Jordan
Limited End Float
Floating Shaft
Cut-Out
Marine Type
Heavy Duty
Shear-Pin

For special applications the standard basic design can be easily altered to meet exact requirements.



Anchor WALDRON Cut-Out Coupling

The Anchor Waldron Cut-Out Coupling combines the features of a flexible Waldron gear coupling with the overload protection of the Anchor Cut-out. Its power "shutoff" action works at the instant a dangerous overload appears. The Anchor Cut-Out Coupling needs no protection from atmospheric conditions such as moisture, grit or dirt.

Francke Pin Type Coupling

In addition to compensating for misalignment, pin units provide a spring cushion for shock loads and transverse vibrations.

Junior Nylon Coupling

Weighs only 2½ oz. and is non-corrosive, non-magnetic and requires no lubrication. ⅜"—½"—⅝" and ¾" hub bores.

Automatic Cut-Out

Positive mechanical unit that makes use of increasing torque to control operation of machine. Saves down-time, protects horsepower.

JOHN WALDRON CORPORATION

A SUBSIDIARY OF MIDLAND-ROSS CORPORATION

NEW BRUNSWICK, NEW JERSEY

Representatives in Principal Cities
Export Agents—Frazar & Co., New York, N. Y.

Transmit Motion This Positive Low Cost Way!

TOUREK *"STANDARD"* BALL JOINTS

TYPE "A" BALL JOINT

Non adjustable spring type with a light pre-set tension. The shell is spun over the top cap bearing and a spring applies the tension of bearings against ball screw. This Ball Joint is used universally in hundreds of applications where excessive pressures would not be applied against the top cap.

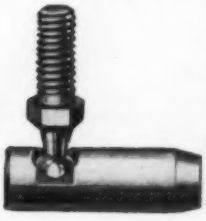
TYPE "EC" BALL JOINT

Ball socket is located in same unit as cross drilled hole, giving added wall thickness. Ball stud with short neck allows more than 250 lbs. force against this unit. Swivel construction is assembled with a grease resistant neoprene washer to cushion movement and maintain proper tension. A spring clip allows rapid adjustment over great length. Stocked for rod sizes ¼" and ⅝".

TYPE "B" BALL JOINT

This is an adjustable spring type Ball Joint with cap bearing slotted one way. The threaded top bearing is assembled to maintain light tension against the bottom bearing and spring. A cotter pin is used to maintain proper adjustment. This type Ball Joint is ideal for applications requiring take up of wear.

TYPE "F" BALL JOINT



Low cost, trouble free unit readily adapted to various rod or shell sizes. Non adjustable type permitting 15° movement in any direction. No retaining devices needed. The type "F" should be applied where the higher cost of adjustable Ball Joints makes it necessary to substitute clevises, trunions, bent rods or other less effective ways to transmit motion.

TYPE "C" BALL JOINT

The type "C" Ball Joint is a positive adjustable type. It has no spring tension. The shell is cross drilled five ways. The fine pitch thread top bearing is inserted and locked by a cotter pin to provide desired free movement. Construction and adjustment features of this Ball Joint make it an outstanding number in the TOUREK line.

NEW SLIP-ON BALL JOINT

For quick assembly in "hard-to-get-at places". Slight retraction of outer shell exposes socket for quick insertion or withdrawal of ball. There are four component parts. 1. Shell 2. Outer housing 3. Spring 4. Ball Screw. This design completely houses compression spring and retains ball screw in its machined socket. Cotter pins, clips, or other retaining devices are eliminated.

Tourek
BALL JOINTS
The Recognized "STANDARD"

MAIL THE COUPON TODAY!

World's largest manufacturer of "STANDARD" Ball Joints. Also makers of Pipe Plugs and quality Screw Machine Products. Ranges up to 2½" diameter single and multiple spindle machines. Operations include: Threading • Tapping • Milling • Drilling • Grinding • Polishing • Plating • Heat Treating • Silver Soldering.

ESTAB. 1920

J. J. TOUREK MANUFACTURING COMPANY
1901 SOUTH KILBOURN AVENUE, CHICAGO 23, ILLINOIS

Gentlemen:

Please mail to me at once, complete information and prices on TOUREK "STANDARD" Ball Joints, Rods and Linkages.

Name_____

Company_____

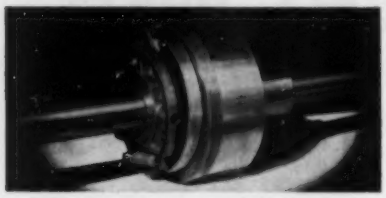
Address_____

City_____ Zone____ State____

POWER TRANSMISSION

THE HILLIARD LINE OF CLUTCHES, COUPLINGS, DRIVE UNITS • •

SINGLE REVOLUTION CLUTCH

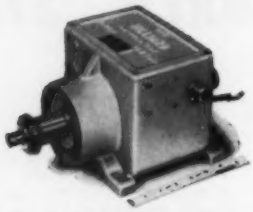


USE. Rivet machines, snap fastener machines, shears, staplers, bottling machinery, cut-off mechanisms, indexing and feeding equipment, packaging processes or wherever controlled intermittent motion is necessary from a continuously rotating source of power.

SPECIFICATIONS

Made in 2 types in 11 standard sizes plus special designs to suit particular applications. Smallest standard size—1¼" diameter x $1\frac{13}{32}$" shaft length. ¼" bore, .04 H.P. @ 100 r.p.m. 2 foot pounds torque normal rating. Speed up to 850 r.p.m. under certain conditions. Largest standard size—17½" diameter x 17⅝" shaft length, bore up to $4\frac{15}{16}$", 176 H.P. @ 100 r.p.m., 9240 foot pounds torque normal rating. Approximate maximum speed 65 r.p.m. Write for Bulletin 239 for further detailed information.

INTERMITTENT DRIVE UNIT



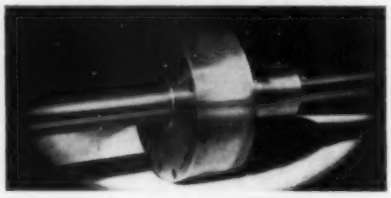
Hilliard's complete, single package unit that converts rotary power to precise intermittent motion . . . clip and bend, shear or slash, oscillate or repeat, raise or lower, index and position. It can be installed on existing equipment, designed into new machinery and reused after production line changes. I.D.U. eliminates the need of buying separate parts to assemble a "custom" machine with assorted mechanisms to apply and control it. Features highly flexible control — manual, mechanical or electrical — permitting "demand" type operations in fixed or variable cycles. A protected drive, totally enclosed in an oil bath housing, it is ideal for dusty, "steamed" or "wash-down" conditions. Bulletin. I.D.U. 2

WEDGE-ROLL

THE NEW OVER-RUNNING CLUTCH

A new improved type of clutch designed for specific application where great torque capacity is needed in a limited space and for high speed operation. Has all the regular features of over-running clutches plus exceptionally low free wheeling resistance and balanced design to result in longer service life. The Wedge-Roll Clutch cannot jam or lock in reverse even after long wear. There are four clutch sizes ranging from 3½" to 7⅛" diameter and from 1.8 to 36 H.P. at 100 RPM. Additional sizes, both larger and smaller, are available on special order. Ask for the Wedge-Roll Bulletin.

OVER-RUNNING CLUTCH



USE: Dual drive, two speed drive or standby drive on boiler stokers, blowers, induced or forced draft fans, dry cleaning machines, ventilating fans and similar equipment.
Also for ratchet feed on presses or automatic back-stop on conveyors or to permit free rotation when the driver slows or stops.

SPECIFICATIONS

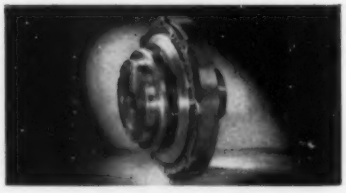
Made in 7 types and 15 standard sizes plus special designs for specific installations. Smallest standard size—$1\frac{13}{16}$" diameter x $1\frac{25}{64}$" shaft length. ⅜" bore, 1/20 H.P. @ 100 r.p.m., 31.5 inch pounds torque normal rating. Largest standard size—25" diameter x 16⅞" shaft length $7\frac{15}{16}$" maximum bore, 394 H.P. @100 r.p.m. 20694 foot pounds torque normal rating. Ask for Bulletin 231 for comprehensive data.

CENTRIFUGAL

AUTOMATIC CENTRIFUGAL CLUTCH COUPLING

Improves starting conditions and provides smooth acceleration on drives for high inertia equipment; prevents excessive torque transmission during starting of textile machinery; prevents torsional resonance on internal combustion engine drives; provides automatic coupling on emergency and dual drive systems; provides overload protection and has exceptional ability to compensate for all types of misalignment. Operating mechanism requires no lubrication. Write for Bulletin CE-3 for additional information.

SLIP CLUTCH



USE: to protect speed reducers or gear trains against destructive overload, to reduce shock in door opening and closing mechanisms, as a safety feature where a machine is subject to jamming or to limit the torque of any drive.
Also to provide constant tension with varying speed as in a reeling or winding application.

SPECIFICATIONS

Made in 15 types and 11 sizes. The torque transmission of all slip units is adjustable and some models can be adjusted while in operation. Smallest clutch (light series)—$2\frac{3}{8}$" diameter x 1¾" shaft length, ½" or ⅝" bore, 9 foot pounds torque maximum capacity. Smallest clutch (regular series) 5¾" diameter x 4¾" shaft length, ¾", 1" or 1¼" bore, 38 foot pounds torque capacity. Largest clutch—27" diameter x $31\frac{3}{8}$" shaft length, bore up to 8" 24600 foot pounds torque capacity. For complete description, request a copy for Bulletin 300.

• HILLIARD CLUTCHES AND COUPLINGS ARE EXCELLENT FOR ALL CLASSES OF INDUSTRIAL MACHINERY

All Products of THE HILLIARD CORPORATION ELMIRA, NEW YORK

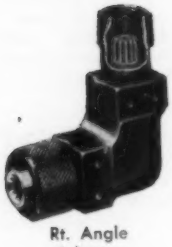
Flexible Shafts

FOR MANY FIELDS

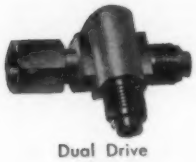
CIRCLE ESS

Circle Ess Flexible Shafts are compact, lightweight, strong, and durable. They transfer power efficiently and economically regardless of obstructions in the path of installation, while insuring the most accurate alignment.

Pictured below are examples of the flexible shaft assembly, and a few of the industries in which flexible shafting has found application. Complete specifications on the cable and casing which make up the flexible shaft assembly are included in our Circle Ess Flexible Shaft booklet. Send for it today.



Rt. Angle Adapter



Dual Drive Adapter

Rt. Angle Ball Bearing Adapter

H Type Adapter

CIRCLE ESS ADAPTERS

are lightweight, compact, durable and offer a number of varied uses. The Dual Drive Adapter pictured here measures only 2-27/32" x 1-61/64" and weighs only 4 oz. For complete adapter specifications send for Flexible Shaft Adapters Catalog.

AIRCRAFT

AUTOMOTIVE

INDUSTRY

MISSILE

ELECTRONICS

ROCKETS

F.W. STEWART CORP.

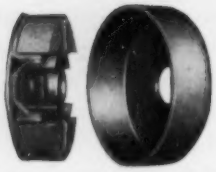
4311-13 RAVENSWOOD AVENUE · CHICAGO 13, ILL.

WEST COAST PLANT: 2404 So. Grand Ave., LOS ANGELES 7, CALIFORNIA

CIRCLE ESS

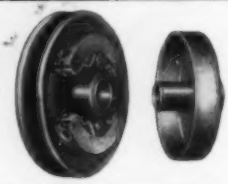
WRITE 277 ON READER SERVICE CARD 277

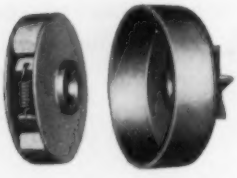
AUTOMATIC CENTRIFUGAL CLUTCHES



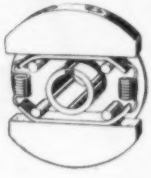
Straight — Simple design, only four moving parts. Interchangeable shoe springs vary engagement speeds. Torque to 12 lb-ft.

Cam Type — Moderate camming action between drive studs and shoe mounting brackets gives engagement and release at approximately the same speed — with or without load. Torque to 25 lb-ft.





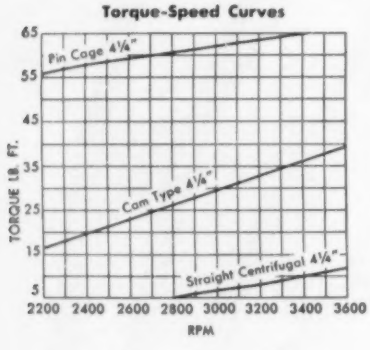
Pin-Cage Type — Camming action multiplies the engagement force — gives high efficiency under heavy load. Torque to 50 lb-ft.



for compact, high-torque drives

Fairbanks-Morse centrifugal clutches are ideal for small gasoline engine drives on equipment that requires easy, no-load starting . . . smooth pickup of high-inertia loads . . . overload protection . . . and reliable engagement at a particular engine speed. They adapt easily to sprockets, pulleys, and gear-type drives — can be mounted quickly and directly to engine or motor shafts. Compact design meets almost any space requirement (max. 4¼" working diam), yet the Pin-Cage model will deliver up to 50 lb-ft of torque at 3600 rpm (see torque-speed curves). Simple design, rugged construction, and heavy-duty parts mean reliable operation and little or no upkeep.

Torque-Speed Curves



For big torque in a small clutch at unusual savings, investigate F-M automatic clutches. A four-page technical bulletin (FM 291) can be obtained by writing Fairbanks, Morse & Co., Magneto Division, Beloit, Wisconsin.

FAIRBANKS-MORSE

A name worth remembering when you want the BEST

MAGNETOS • REWIND AND ELECTRIC STARTERS • WATER SYSTEMS • GENERATING SETS • PUMP MOTORS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • CLUTCHES AND TRANSMISSION

catalogs and bulletins . . . . . continued

(E-106) **Gears**—Brochure, 5 pp. Describes capacity of equipment, types of gears and facilities available. The Cincinnati Gear Co, Wooster Pike & Mariemont Ave, Cincinnati 27, Ohio.

(E-107) **Flexible Couplings**—Catalog, 5 pp. Multi-piece coupling ranges from 1/25 hp through 40 hp while single unit model has range from ⅓ hp through ¾ hp. Guardian Products Corp, 1215 E 2nd St, Michigan City, Ind.

(E-108) **Bevel Gears**—Brochure, 40 pp. Describes design systems for straight and spiral bevel gears. Gleason Works, 1000 University Ave, Rochester, NY.

(E-109) **Power Transmission Equipment**—Brochure, 8 pp. Brief technical description of design parameters and applications of actuators, motors and mechanical power transmission equipment. Hoover Electric Co, 2100 S Stoner Ave, Los Angeles 25, Calif.

(E-110) **Gears**—Brochure, 4 pp. Shows manufacturing facilities, current products and gives sales information. Chas E Crofoot Gear Corp, Central St, South Easton, Mass.

(E-111) **Gears and Speed Reducers**—Catalog, 186 pp. Presents selection data, weights, rpm charts, dimensions, ratios, assembly information and engineering tables for speed reducers, gears and sprockets. Ohio Gear Co, 1333 E 179th St, Cleveland, Ohio.

(E-112) **Worm Gear Speed Reducer**—Bulletin, 8 pp. Contains ratings, ratios, prices and dimensional drawings. Covers single, double and triple reduction units. Brad Foote Gear Works, Inc, 1311 S Cicero Ave, Cicero 50, Ill.

(E-113) **Magnetic Particle Clutches and Brakes**—Bulletin, 4 pp. Describes construction, component parts and principles of operation; gives outline dimensions, typical performance characteristics, applications and prices. Vickers Inc, Electric Products Div, 1815 Locust St, St Louis 3, Mo.

(E-114) **Variable Speed Drive System**—Bulletin, 16 pp. Photos and diagrams of operation, manufacture and functions of components. Also lists specifications, dimensions and accessories. Reliance Electric & Engineering Co, 24701 Euclid Ave, Cleveland 17, Ohio.

(E-115) **Gears and Axles**—Catalog, 34 pp. Covers axles, hubs, springs, drawbars, wheels, special running gear, 2- and 4-wheel assemblies. Engineering drawings, military and commercial specifications included. The United Mfg Co, 5250 Dobeckmun Ave, Cleveland 2, Ohio.

(E-116) **Couplings**—Catalog, 20 pp. Contains description of the various types of gear couplings, including the standard floating shaft, spacer type, heavy duty, shear pin, and others. John Waldron Corp, PO Box 791 New Brunswick, NJ.

catalogs and bulletins.....continued

(E-117) Gears—Catalog, 88 pp. Describes gears and their component parts, showing pitch diameters. Also, miniature gears and differentials. Dynamic Gear Co, Inc, 20 Merrick Rd, Amityville, NY.

(E-118) Flexible Shafting—Brochure, 8 pp. Explains the advantages of utilizing flexible shafting in product design. Data listed on remote control and power drive cable, casing and adapters. F W Stewart Corp, 4311 Ravenswood Ave, Chicago 13, Ill.

(E-119) Speed Reducers—Bulletin, 24 pp. Details line of double-enveloping worm gear speed reducers. Stocked capacities range from fractional to 665 hp; reductions from 5:1 to 70:1. Specifications on extended and hollow shaft models, drawings, tables of mechanical, thermal hp, and other ratings. Cone-Drive Gears, Div Michigan Tool Co, 7171 E McNichols Rd, Detroit 12, Mich.

(E-120) Worm Gear Reducers—Brochure, 8 pp. Hp ratings and selection tables for 3 in. through 14 in. centers. Also, includes standard ratios and efficiency figures. David Brown Inc, 999 Beecher St, San Leandro, Calif.

(E-121) Miniature Clutches—Catalog, 6 pp. Gives engineering and construction data, sizes and prices for stock units with nonreversing, overrunning, single revolution and indexing applications. Precision Specialties, Inc, 1342 E 58th St, Kansas City, Mo.

(E-122) Gear Speed Reducers—Catalog, 24 pp. Shows assembly diagrams, construction features, dimensions and hp ratings. Also discusses service factors, efficiency and selection of units. Brad Foote Gear Works, Inc, 1311 S Cicero Ave, Cicero 50, Ill.

(E-123) Industrial Clutches—Catalog, 39 pp. Covers single revolution, over-running slip and centrifugal clutches, and clutch couplings plus packaged intermittent drive unit. The Hilliard Corp, 100 W Fourth St, Elmira, NY.

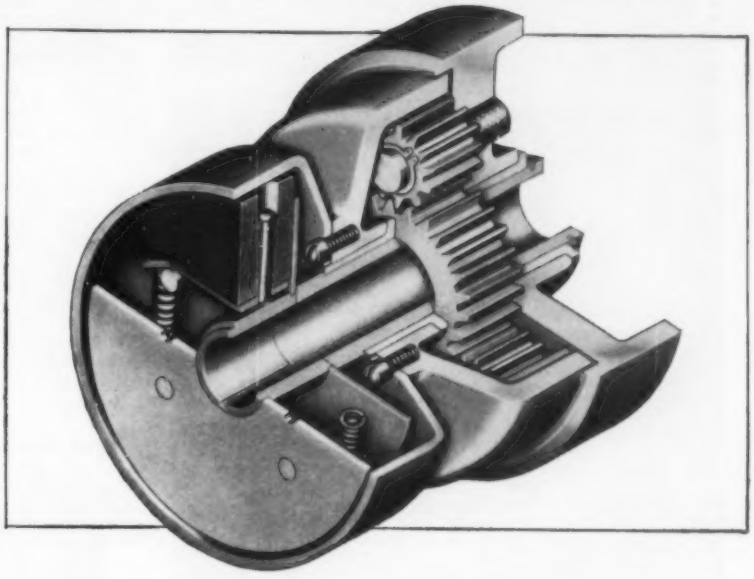
(E-124) V-belting—Catalog, 24 pp. Contains installation directions pictorial section, types and sizes of belt, and packaging information. Manheim Mfg & Belting Co, 246 Manbel St, Manheim, Pa.

(E-125) Gear Reducers and Adapter Kits—Catalog, 16 pp. Contains description, applications and specifications of precision reduction units; gives available ratios and lists adapter kits available for mounting gear reducers on servo motors. Link Aviation, Inc, Hillcrest, Binghamton, NY.

(E-126) Variable-speed Drives—Bulletin, 8 pp. Includes mechanical construction features, specifications, available speed variations, controls and accessories. Reeves Pulley Co, Div Reliance Electric & Engineering Co, 1225 Seventh St, Columbus, Ind.

(E-127) Flexible Shafting—Bulletin, 12 pp. Design information for selecting flexible shafting sizes from $\frac{1}{8}$ in. to $1\frac{3}{8}$ in. Stow Mfg Co, 441 Shear St, Binghamton, NY.

PACKAGED REVERSIBLE TRANSMISSION



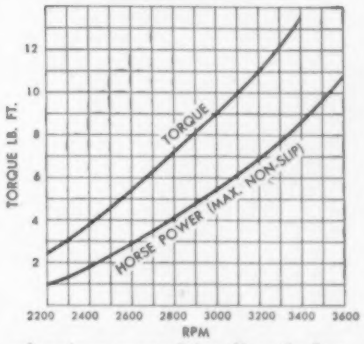
for small gasoline engines

Design powerful new sales appeal into your next year's models with this new, low-cost, automatic forward-reverse transmission.

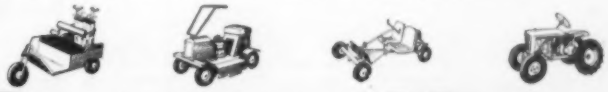
Mounted to the crankshaft of 1-1/2 to 5 hp engines, these compact (3-7/8″ by 4-5/16″) drives provide no-load starting . . . automatic engagement at best engine speed . . . and smooth reverse. All without gear shifting.

Forward drive clutch has a unique camming action. This multiplies the engaging force and gives you high torque in a small space (see torque speed curves, right). It provides a positive drive at operating speeds — yet prevents equipment damage due to overloading. Interchangeable shoe springs permit a wide range of engagement speeds, from 1150 to 2700 rpm. Rugged, reverse planetary gears drive directly from the crankshaft—can't jam or strip.

Torque-Speed Curves



Write for Bulletin FM-296: Fairbanks, Morse & Co., Magneto Division, Beloit, Wisconsin.



FAIRBANKS-MORSE

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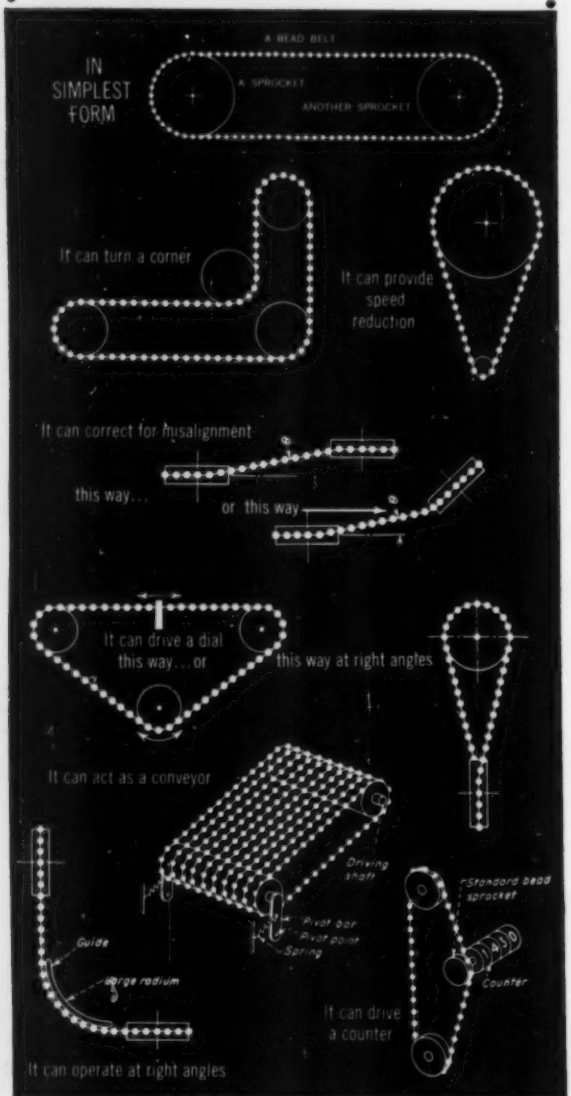
MAGNETOS • REWIND AND ELECTRIC STARTERS • WATER SYSTEMS • GENERATING SETS • PUMPS
MOTORS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • CLUTCHES AND TRANSMISSIONS

WRITE 279 ON READER SERVICE CARD 279

What Can A Bead Belt Drive Do That Other Drives Cannot?

where torque and speed requirements are low, or drive components are inaccessible . . .



Or it can perform a combination of these functions—all without slipping! Think of the exciting new design freedom this exceptional flexibility and low unit cost offers you! Such low cost versatility has won **Bead Belt Drives** wide use in business machines, TV, radio, washers, dryers, scientific apparatus, animated displays, many others. For complete information, write for Bulletin BB.

VOLAND & SONS, INC.,

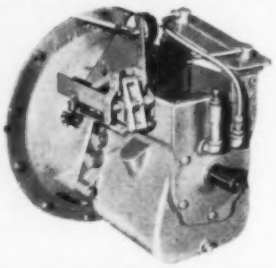
27 Centre Avenue, Dept. P-9, New Rochelle, N. Y.

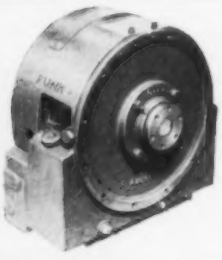
CUSTOM-BUILT Power Transmissions from Standard FUNK Components

FUNK Modular Units can be combined in an unlimited number of power transmission arrangements, quickly and economically—without special engineering costs. Only 3 standard flanges do the trick—fit practically any unit to any machine and any need. You get a custom-made system—at a production-line price. Our engineering department will be glad to work with you.

REVERS-O-MATIC® DRIVES

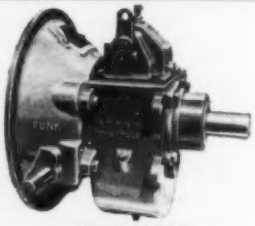
A single throttle lever changes your direction and speed of travel and controls this compact combination of hydraulically operated clutch and torque converter. It's the simplest control yet devised for shuttle movement—up and down—forward and reverse. *Smooth, instant, positive* action—without shock. Standard flanges readily adapt to other components. Ideal for road rollers, hoists and shovels.





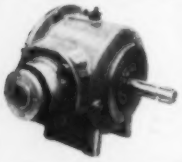
TORQUE CONVERTERS

A diversified line of compact short-coupled units. Fit SAE housings. Standard flange system adapts to any other Funk equipment.



REVERSING TRANSMISSIONS

A rugged, synchronized shift for fast reversals. Eliminates bringing machine to a complete stop to change direction. Ideal for loaders, conveyors and winches. Pictured with heavy-duty clutch housing.



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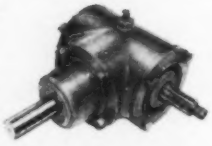

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catalogs and bulletins . . . . . continued

(E-128) Transmission—Brochure, 8 pp. Consists of two planetary systems for low and reverse plus multiple disk clutch for direct drive. Gives dimensions, speeds and torque capacity data. American Gear & Mfg Co, Subsidiary of Brad Foote Gear Works, Inc, New Ave, Lemont, Ill.

(E-129) Universal Joints, Drive Shafts and Assemblies—Catalog, 4 pp. Illustrations and applications of standard joints from 350 to 89,300 torque in. lbs continuous load capacity. Rockwell-Standard Corp, Universal Joint Div, Allegan, Mich.

(E-130) Power Transmission Belting—Catalog, 36 pp. Lists types of belts, hp ratings, belt speeds, motor base selection, proper maintenance, and uses of leather packings. Alexander Brothers, Franklin & Suffolk Sts, Worcester 4, Mass.

(E-131) Gearmotors and Speed Reducers—Bulletin, 20 pp. Describes ratings, types, dimensions, specifications, list prices and ordering information. Janette Electric Mfg Co, 8350 N Lehigh Ave, Morton Grove, Ill.

(E-132) Lightweight Power Units—Brochure, 17 pp. Dimensions, specifications and performance data concerning small windmills which absorb energy from an aircraft's slipstream and convert it to electrical or hydraulic power for emergency or operational uses. Aeroproducts Operations, Allison Div, GMC, Municipal Airport, Dayton 1, Ohio.

(E-133) Sprockets and Roller Chain—Catalog, 80 pp. Shows dimensions, hp ratings, table of speed ratios for sprocket combinations, list prices, strengths and weights. Data is also presented on flexible couplings, universal joints and cadmium plated shaft collars. Union Gear & Sprocket Corp, 111 Penn St, Quincy 69, Mass.

(E-134) Variable-speed Drives—Catalog, 12 pp. Contains description of principles of operation, features, selection charts, application examples, special controls available, listing of types and sizes, special modifications, and sales information. Graham Transmissions Inc, Menomonee Falls, Wisc.

(E-135) Gears and Shafts—Catalog, 4 pp. Lists sizes and types, production capacities, gear ratios, pitch and diameters of helical spur, bevel, miter and worm gears. The Adams Co, Dubuque, Iowa.

(E-136) Power Transmission and Conveyor Products—Catalog, 104 pp. Includes specifications, speed ratios, chain length tables, illustrations and prices on roller chain, sprockets, couplings and conveyor chain. Diamond Chain Co, Inc, 402 Kentucky Ave, Indianapolis 7, Ind.

(E-137) Gears and Speed Reducers—Bulletin, 4 pp. Describes construction materials and diametral pitches for line of gears: bevel, miter, spur, helical, nonmetallic and worm types; special gears and speed reducers are also covered. Ohio Gear Co, 1200 E 179th St, Cleveland 10, Ohio.

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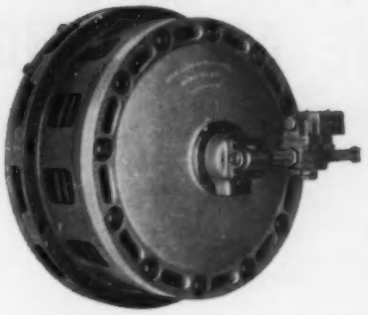

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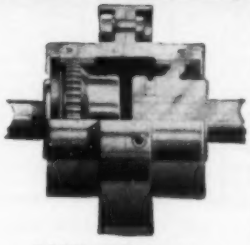

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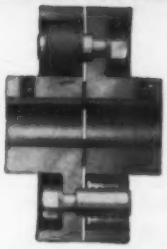

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E POWER TRANSMISSION

HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS

1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM)—If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example.)

3. Operating Radius—In making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

RATINGS—The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)

2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.

3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	.185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

EXAMPLE—How to use the table:
The problem is to transmit ½ HP at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in.)—
$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$
2. Correction factor for starting torque 1.5 x 18.5 = 27.75
3. Correction factor for unsupported shaft 27.75 x 1.6=44.4 lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core No. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divided by 1700. 54 × 1500 ÷ 1700 = 47.6 lb. in (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

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catalogs and bulletins.....continued

(E-138) High-speed Gears—Bulletin, 22 pp. Construction details, specifications, performance characteristics, application, selection and hp tables, service factors and shaft speeds for pipeline, air conditioning and special drives. Western Gear Corp, Industrial Products Div, PO Box 126, Belmont, Calif.

(E-139) Rotary Oscillating Torque Actuators—Catalog, 20 pp. Used in automation equipment and machine tools for indexing, clamping, feeding and turning over parts. Describes mounting variations, controls, dimensions, torque ratings and application possibilities. Ex-Cell-O Corp, 945 E Sater St, Greenville, Ohio.

(E-140) Transmission Products—Catalog, 232 pp. Contains dimensions, hp ratings, diagrams and photographs of various gears, ratchets, pinion wire, flexible couplings, universal joints and speed reducers. American Stock Gear Div, Perfection Gear Co, 152nd St & Vincinnes Rd, Harvey, Ill.

(E-141) Precision Instrument Gearheads—Brochure, 8 pp. Describes construction and gives standard ratios and other engineering information. Washington Machine & Tool Works Inc, 13111 Wayzata Blvd, Minneapolis 26, Minn.

(E-142) V-belts—Catalog, 26 pp. Gives selection data, hp ratings, construction materials, service factors and tension formulas for line of v-belt drives. Durkee Atwood Co, 215-7th St NE, Minneapolis, Minn.

(E-143) Clutch-pulley Package—Brochure, 10 pp. Describes operation and construction. Gives selection and dimension information. Warner Electric Brake & Clutch Co, Beloit, Wis.

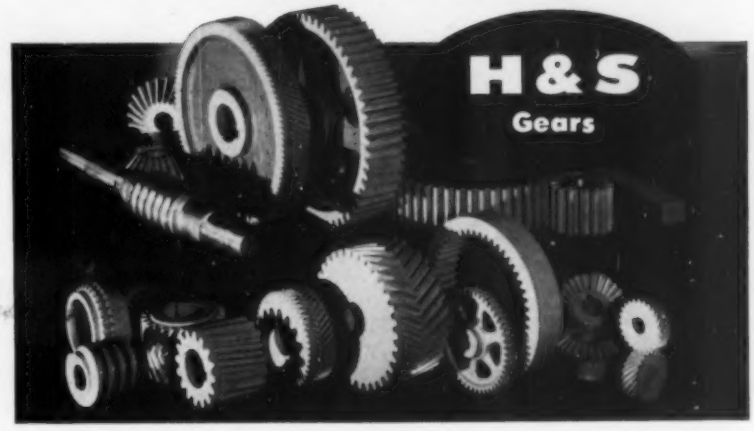
(E-144) Gears, Flexible Couplings, Universal Joints and Collars—Catalog, 48 pp. Gears ranging from 16 dp to 3 dp, spur, miter, bevel, worm gear types. Roller chain type flexible couplings for shafts from ⅜ in. to 6¼ in. diameter. Universal joints for shafts from ½ in. to 2½ in. diameter in both steel and bronze. Union Gear & Sprocket Corp, 111 Penn St, Quincy 69, Mass.

(E-145) Hydraulic Power Units—Brochure, 4 pp. Operational and construction features of power units for industrial and missile ground support applications are illustrated. The Rucker Co, 4700 San Pablo Ave, Oakland 8, Calif.

(E-146) Magnetic Conveying Devices—Bulletin, 4 pp. Fastened under conveyor belts moving ferrous materials. Installation, construction, and magnetic strength information together with photographs and drawings. Eriez Mfg Co, 1945 Grove Drive, Erie, Pa.

(E-147) Conveyor Belts—Catalog, 28 pp. Material weight charts, belt capacities, hp requirements, application factors, and other engineering charts and tables. Raybestos-Manhattan, Inc, Passaic, NJ.

Gears and Speed Reducers
for your power transmission needs



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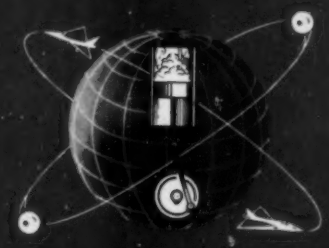
SECTION F

MECHANICAL PARTS AND DESIGN ANALYSIS



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DESIGN ABSTRACTS

CUMULATIVE DAMAGE INVESTIGATED

In the application of various damage accumulation hypotheses to shock and vibration problems, a pattern of results was observed. In each case the results could be presented as a graph of the allowable maximum stress response versus the applied number of shocks for various values of structural damping. Changes in the distribution of load amplitudes also shifted these curves as a group. As a consequence of these observations, it seemed possible that a generalization of damage accumulation could be made somewhat as follows: Total damage accumulated = (amplitude of maximum response factor) × (distribution of load amplitudes factor) × (material and structure factor).

More rational specs

If such a generalization could be made, then the writing of specifications and the design processes for shock and vibration could be greatly simplified and, at the same time, made more rational. It might even be possible to include factors for the damage contributed by other loads, such as thermal expansion, pressure cycles, mechanical loads, and the like. The following developments lead to one form of such a generalization.

Fatigue Test Data

Presently available relationships should be put together to form the various factors in the above equation. First, it is reasonably well established that fatigue tests of steels give the relationship: $yN^k = C_1$ where y = stress for stress fatigue, or plastic strain for strain fatigue, N = number of cycles to failure at y, $k = \frac{1}{2}$ for stress fatigue, or $\frac{1}{2}$ for plastic strain fatigue, C_1 = constant for each material.

The paper then goes on to discuss: Structural response to transient loads, damage accumulation, stress or strain range per cycle of response to transients, damage accumulation per transient load, damage accumulation from a series of transients, inclusion of other kinds of loads, and effect of mean stress.

"A Generalization of Cumulative Damage," R M Mains, Knolls Atomic Power Laboratory, ASME paper No 59—Met-1, 29 W 39th St, New York 18.

*

Maxima and Minima

The useful application of differential calculus to the determination of maxima and minima is well known to engineers, but it is not usually appreciated that partial differentiation considerably shortens calculation. The method is discussed in relation to engineering practice.

"Problems in Maxima and Minima," W H Sheppard, Mechanical World, Apr '59, 31 King St West, Manchester 3, England.

*

Tangential Residual Stress Distribution in Curved Beams

A method of determining tangential residual stress distribution in curved beams of rectangular cross-section is based upon the fact that when a thin layer is removed from the periphery of the beam, radius of curvature of beam changes. Stress in the layer removed may then be calculated —laboriously on a desk calculator, more easily with a computer.

Abstracted from "A Theory for the Calculation of Tangential Residual Stress Distribution in Curved Beams," by J L Rembowski, General Motors Corp.; SESA paper 473, Central Square Station, PO Box 168, Cambridge 39, Mass.

*

How Relaxation Affects Material Under Combined Stress

How a material subjected to combined alternating and static stresses reacts to relaxation may be represented by two nonlinear Maxwell units. These make it possible to describe behavior quantitatively and permit computation of fatigue stress range diagram. Three stages are produced in those diagrams developed for notched specimens; stages can be analyzed at present.

"Effect of Relaxation on Behavior of Materials Under Combined Alternating and Static Stress," F H Vitovec, University of Wisconsin, ASME paper 59-Met-3, 29 W 39th St, New York 18.

*

Conveyor Chains

Engineering and application data for six types of conveyor chains especially applicable to the continuous transport of small and moderate sized items and containers. These chains are used in breweries, dairies, canneries, carbonated beverage plants, food processing plants, distilleries, pharmaceutical houses, light to moderate manufacturing operations, chemical plants, petroleum products plants, cosmetic plants, and many other industries.

"Table Top Conveyor Chains," Bulletin 56-60, Chain Belt Co, Milwaukee 1, Wis.

*

Rubber Engineering

Described are: Experiments to determine the form of the stress/strain relationships in compression for flat rubber pads of circular, rectangular, and square cross sections as well as pads of circular cross section with a central hole, under static and dynamic conditions and under bonded or lubricated conditions.

The effect of fillers in the rubber composition on these relationships is also discussed. Next, the static and dynamic stress/strain relationships for a rubber mounting deformed in shear are considered, and the experimental results shown to be in conformity with the theory derived from classical elasticity theory. The shape function and shape factor of a shear mounting are discussed. From a combination of the shape functions in shear and in

compression, a theoretical expression for the stress/strain relationship for a combined shear and compression mounting is derived which agrees well with experiment.

"Shape Factors and Functions in Rubber Engineering," A R Payne, Research Association of British Rubber Manufacturers, Shawbury, Shrewsbury, Shropshire; The Engineer, Feb 27, '59, 28 Essex St, Strand, London, WC2.

*

Effect of Residual Stress on Fatigue Strength

Rotating tests performed on notched bars, preloaded to induce residual stress, are reported. Effect depends on material and notch contours.

"Effect of Residual Stress on Fatigue Strength," D S Dugdale, University College of Swansea (England); Welding Journal, Jan '59, 33 W 39th St, New York 18.

*

Friction, Wear and Deformation

Results of investigations of the effects of sliding friction and wear on wood, diamond, glass, rubber and metallic carbides are described. Other experiments are also discussed, including some on friction effects at high speeds, damage to solids by impact with liquid at very high speeds, deformation of metals and nonmetals.

"Some Recent Experiments on Friction, Wear and Deformation of Solids," F P Bowden, Cambridge University (England); SAE paper 17R.

*

Lateral Vibrations in Reciprocating Machinery

Application of periodic torque to shafts driving overhung mass in rotating electrical, mechanical and hydraulic machinery tends to excite lateral vibration or "whirl." When torsional and lateral natural frequencies are close to each other, torque tending to excite harmonic order of natural frequency will also excite lateral natural frequency.

Equations are given for preliminary calculation of torsional natural frequency, torque-variation frequency and lateral natural frequency. With such data, shaft and flywheel sizes can be chosen so that frequencies can be adequately separated.

"Lateral Vibrations in Reciprocating Machinery," C M Lowell, Worthington Corp., ASME paper 59-A-79.

*

Propeller Static Thrust

Since the subject of propeller-driven VTOL aircraft started to receive considerable attention recently, some branches of the aircraft industry and some research agencies have been focusing much interest on the static thrust of propellers. Where a propeller is to be used as a means of providing the static thrust and thus the lift for a vertical take-off type of aircraft, the subject of static thrust becomes all important.

Presented is a brief treatment of the basic theory involved, a presentation of the available test data, and a general method for the rapid computation of static thrust using a static efficiency (or figure of merit) term.

"Propeller Static Thrust," Ken S Coward, Ryan Aeronautical Co; Aero/Space Engineering, Mar '59, 2 E 64th St, New York 21.

*

Fasciculated Springs

Clustered (fasciculated) torsion springs occupy less space than suspension springs. But there's more than that to splitting the suspension load, study shows.

The weight of a spring for a given maximum stress is determined by the energy it can absorb and store, an ability which is the measure of its efficiency. In this particular problem, the over-all volume of the spring and its flexibility (not the volume of the spring material) are the prime considerations. Thus, the initial requirements preclude the use of any material but steel, and eliminate various spring types.

Torsion bar best

For example, the most efficient springs (tension bar and thin-walled torsion tube) are unacceptable because of manufacturing difficulties. Helical and volute springs waste too much space (for they enclose a relatively large core) and the leaf spring is the least efficient type. The solid torsion bar is thus the only logical choice of spring element.

Permissible maximum stress, and the required rate of deflection, determine the operative length of the torsion bar. The length of solid bar for this problem is found to be quite considerable and rules out its use for space considerations. The only solution is to split the load, and replace the single torsion bar by a number of bars of smaller section and correspondingly shorter length.

The component bars of such a fasciculated torsion spring may be disposed either in a space or a contact pattern and their cross-sections may assume the form of any geometrical figure. Torque and max shear and other formulas are tabulated.

"Tight Space—Try Fasciculated Springs," S Mordasewicz, Army Development Establishment, Design Engineering, Feb '59, 481 University Ave, Toronto, Canada.

*

Tubes Under Combined External Pressure and Axial Load

Relationship between external pressure and axial load at failure was investigated for tubes which fail by plastic buckling under external pressure alone. Experimental techniques and observations are given. An attempt is made at correlating results with relevant formulae for elastic materials.

Abstracted from "Failure of Tubes Under Combined External Pressure and Axial Load," by W Stuiver, General Electric Co, and P F Tomalin, English Electric Co.; Society for Experimental Stress Analysis paper 479, Central Sq Station, PO Box 168, Cambridge 39, Mass.

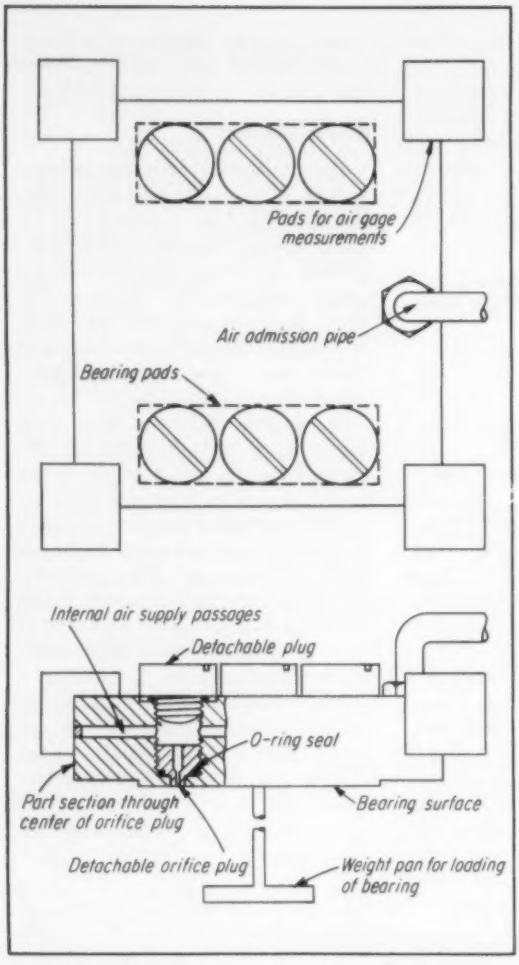

Fig. 1—General arrangement of experimental equipment. Air is admitted to the bearing at one point and distributed to the six orifices through internal manifolds. Orifice outlet can be set-back from bearing surface any desired amount.

Design Data

Problem is one of optimum design for maximum stiffness, maximum load and economic air flow. Tests on flat air bearings to determine relation-slip between design parameters such as bearing area, orifice diameter, bearing lift and load.

H. L. WUNSCH
Mechanical Engineering Research Laboratory
East Kilbride, Glasgow

From: Metalworking Production

Air bearings are being used for a variety of applications but there is a lack of information for systematic design. Problem is one of optimum design based upon maximum stiffness, maximum load and economic air flow.

A fundamental investigation on a flat air bearing determines the relationship between design parameters such as bearing area, orifice diameter, bearing lift and load. Tests are confirmed by two geometrically similar bearings of different bearing area, and the results are only valid for bearings geometrically similar to the ones tested.

EQUIPMENT AND PROCEDURE

Two sizes of bearings are used: (1) two equal pads each 4½ by 1½ in. (13½ sq in.), with three air admission holes in each pad spaced along the center line and with 1½ in. between holes; (2) geometrically similar to first, but pads are 3 in. by 1 in. (6 sq. in.), and air holes spaced 1 in. apart. Fig. 1 shows general arrangement.

Detachable plugs permit various orifice diameters to be tested, and at the same time allowing the outlet of the orifice to be arranged either flush with the bearing surface or set-back by any desired amount. Bearing surfaces are ground and lapped to a high degree of flatness and the bearing floats on a similarly finished base. Pegs limit horizontal movement to $\frac{1}{8}$ in maximum.

Air gages are supported over the four flat and co-planer corner pads; required lift readings are obtained on a mercury column, which can be read to an accuracy of 0.01 in. mercury equivalent to a bearing movement of 3×10^{-6} in. Free air flow is measured on a rotameter accurate to 2% of the full scale reading.

Test procedure consisted of taking lift and flow readings for each condition of load and supply pressure. Zero position is where the bearing and base plate are in contact, the air supply being off. Plotted values are the mean of the four corner readings taken with both increasing and decreasing lift.

Repetition of lift readings are about 0.00003 in. for any set of readings, varying either load or supply pressure. If the bearing is removed from the base plate and replaced again between two readings, repetition is approximately

for Flat Air Bearings

0.00005 in. If, in addition, the orifice plugs are removed and replaced between sets of readings, repetition then becomes 0.00015 in. In the latter case, variations of set-back, however slight, may cause some lack of repetition. Hence, variations in lift, *h*, in the curves should not be assessed closer than 0.00005 in.

VARIATION OF ORIFICE DIAMETER AND SET-BACK

To investigate the effect of changes in orifice diameter and set-back on the flow, lift and stiffness, a series of tests were performed. Supply pressure was constant at 40 psi for five orifice diameters, each $\frac{1}{8}$ in. long, 0.010, 0.015, 0.020, 0.025 and 0.030 in., and four orifice set-backs of 0, 0.003, 0.005, and 0.009 in. Load was increased from 8 lb to 90 lb in 5 lb increments.

Lift against load for different set-backs and constant orifice diameters is shown in Fig. 2. Fig. 3 is for a constant set-back of 0.009 in. and varying orifice diameters. Fig. 4 indicates the effect of varying flow using a fixed orifice diameter but various set-backs. The effect of the orifice set-back on the lift of the bearing is shown in Fig. 5, where the results are plotted under a fixed load and five different orifice diameters.

VARIATION OF SUPPLY PRESSURE

The effect of varying air supply pressure to the bearing was investigated with pressures of 20, 40, 60 and 80 psi. Orifice diameter was 0.020 in. and set-backs used were 0 and 0.003 in. A typical set of lift vs load curves is shown in Fig. 6; Fig. 7 indicates the flow vs load.

Also, measurements of the variation of lift for small changes in supply pressure were made. Applied loads of 20 and 50 lb were used and the pressure varied in small steps from 80 psi until the air film supporting the bearing collapsed. Fig. 8 shows the results of this test. A comparison of the results in Fig. 8 with corresponding values obtained from Fig. 6 shows reasonable agreement to within the specified accuracy of determination.

VARIATIONS IN ORIFICE PLUG DIAMETER

On effect of varying the diameter of orifice plug and hence the area of the orifice set-back, some earlier tests were repeated using a $\frac{1}{4}$ in. orifice plug diameter instead of a $\frac{1}{8}$ in. dia. Orifice diameters tested were 0.015, 0.020, 0.025 and 0.030 in., and set-backs of 0, 0.003, 0.005 and 0.009 in., all at 40 psi supply pressure. Fig 9 shows a typical set of lift vs load curves.

TEST RESULTS

As previously mentioned, lift and load, load capacity, stiffness, supply pressure and lift, air flow required, size of bearing, and set-back area were the design parameters under investigation.

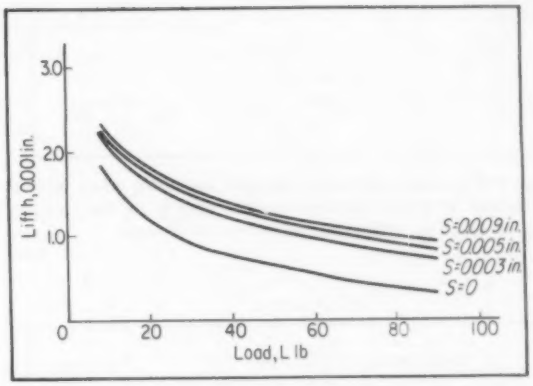

Fig. 2—Lift vs load for different orifice set-backs. Load increases as set-back increases. Curves are for 13½ sq. in. bearing, 0.010 orifice dia and 40 psi constant air pressure.

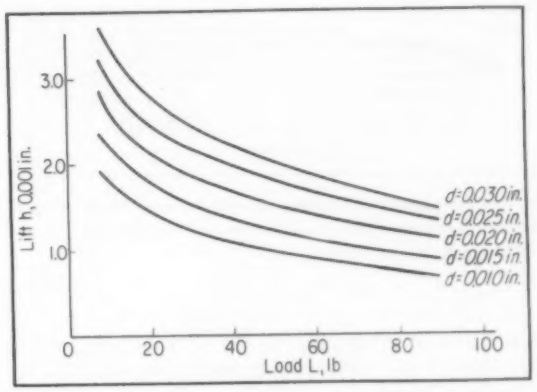

Fig. 3—Lift-load curve for different orifice diameters. Curves are similar until they approach zero lift. 13½ sq in. bearing, 0.009 in. set-back and 40 psi constant air pressure.

Lift and load. From the graph of lift vs load, Fig. 2, in general, the curves all follow a similar course until they approach the zero lift position, when they fall off at a steeper gradient to zero.

Orifice set-back increases the lift up to a certain value of set-back, beyond which no effect is noticeable. These tests indicate a set-back of 0.009 in. to be sufficient to obtain the maximum effect in the 13½ sq. in. bearing,

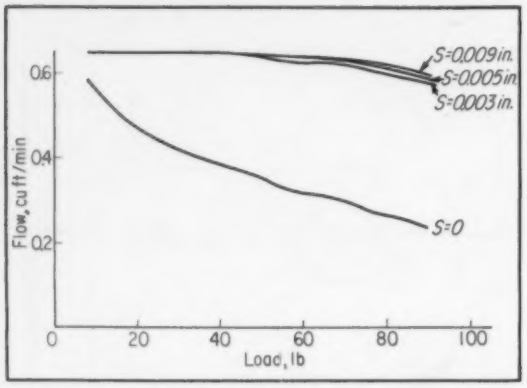

Fig. 4—Flow-load relationship changes noticeable when set-back is reduced to zero. Conditions are the same as for the curves of Fig. 2, 0.010 in. orifice dia and 40 psi air pressure.

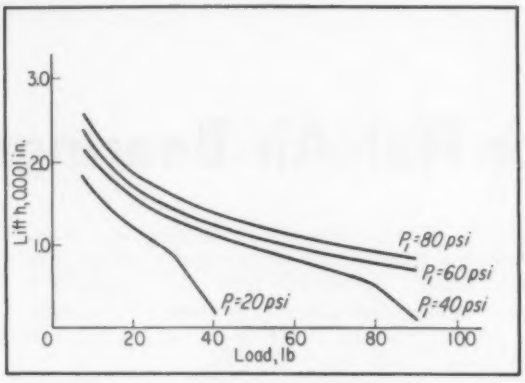

Fig. 6—Load-bearing capacity of 6 sq in. bearing. As lift approaches zero, slope of curves increase sharply. 0.020 in orifice dia, 0.003 in. set-back.

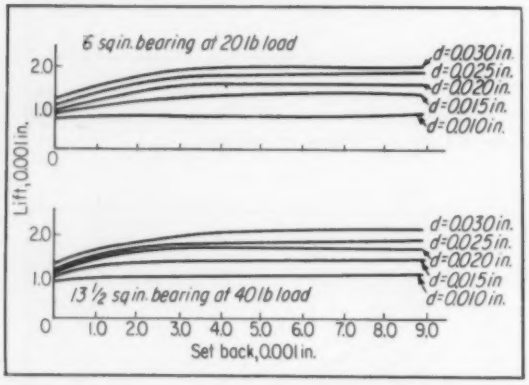

Fig. 5—Orifice set-back increases the lift up to a certain value of set-back. Maximum effect is 0.003 in. for 6 sq in. bearing and 0.009 for 13½ sq in. bearing.

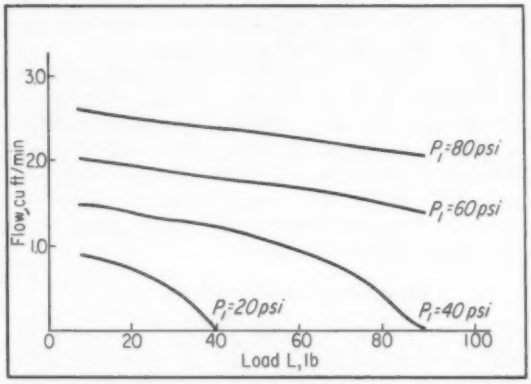

Fig. 7—Flow-load relationship of 6 sq in. bearing. At 60 psi air supply and over flow decreases as load increases; for lower pressures it falls sharply.

while 0.003 in. is adequate for the 6 in. bearing, Fig. 5. This effect is also noticeable in the load-bearing capacity of the 6 in. bearing.

Load capacity. Relation of load-bearing capacity to supply pressure and bearing area is shown for the smaller bearing in Fig. 6. Larger bearing could not be loaded to its full capacity. Maximum load-bearing capacity requires a 0.003 in. set-back.

Values from the curve are about 40 lb and 20 psi and 90 lb for 40 psi supply pressure. If load capacity, L_{max}, equals supply pressure, P, and bearing area, a, times a constant, X; then X is about 0.333, which checks with previous laboratory tests.

Stiffness. Figure for stiffness is the reciprocal of the gradient of the load-lift curves at any point. Stiffness increases with load for any combination of orifice diameter, set-back, supply pressure, and others.

Values of bearing stiffness for various orifice diameters and supply pressures are shown in Table I. From these it appears that there is a tendency for the stiffness to decrease as the orifice diameter increases, though this is subject to some scatter.

Bearing size. For similar orifice diameters, set-backs and supply pressures, the larger bearing floated at a higher level, the lift, however, being less than proportional to the bearing area.

At lower loads, 20 lb, the 6 in. bearing is stiffer than the 13½ in. bearing, but as the load increases the difference disappears, and at loads of 60 lb or more the smaller bearing is less stiff. This is caused by the bearing approaching its load limit so that the air film is beginning to collapse.

Set-back area. The difference in plug diameter, ⅛ or ¼ in., which quadrupled the set-back area did not have any appreciable effect on lift or stiffness, Fig. 9. But the bearing was not tested to its full-load capacity so it was

Table I—Stiffness of Air Bearings (lb/in. x 10^4)

Load	Orifice diameter, in. 0.010	0.015	0.020	0.025	0.030
20	3.6	3.3	2.9	3.1	2.2
40	7.3	7.2	5.6	5.5	4.1
60	10.0	9.7	10.0	7.2	6.3
80	25.0	16.2	12.5	10.0	8.5

Bearing area = 13½ sq in.
Set-back = 0.009 in.
Supply pressure = 40 lb/sq in.

Load	Orifice diameter, in. 0.010	0.015	0.020	0.025	0.030
20	4.5	3.3	3.0	2.7	2.2
40	8.3	8.2	5.5	4.6	4.1
60	12.5	8.2	6.4	5.5	5.5
80	10.0	4.5	5.0	4.1	4.1

Bearing area = 6 sq in.
Set-back = 0.009 in.
Supply pressure = 40 lb/sq in.

Load	Pressure, psi 20	40	60	80
20	3.3	2.5	2.5	2.4
40	3.8	5.6	6.3	5.5
60	...	12.5	10.0	7.1
80	...	12.5	12.5	16.5

Bearing area = 13½ sq in.
Set-back = 0
Orifice diameter = 0.020

Load	Pressure, psi 20	40	60	80
20	...	2.9	3.6	3.1
40	...	7.1	8.3	6.3
60	...	...	10.0	12.5
80	...	...	...	16.6

Bearing area = 6 sq in.
Set-back = 0 in.
Orifice diameter = 0.020 in.

Load	Pressure, psi 20	40	60	80
20	2.6	3.9	2.4	2.2
40	4.5	5.0	5.5	5.5
60	6.3	8.4	7.1	7.1
80	...	12.5	12.5	10.0

Bearing area = 13½ sq in.
Set-back = 0.003 in.
Orifice diameter = 0.020 in.

Load	Pressure, psi 20	40	60	80
20	2.8	2.9	2.5	2.7
40	...	6.3	6.3	5.5
60	...	7.1	7.1	7.1
80	...	...	12.5	20.0

Bearing area = 6 sq in.
Set-back = 0.003 in.
Orifice diameter = 0.020 in.

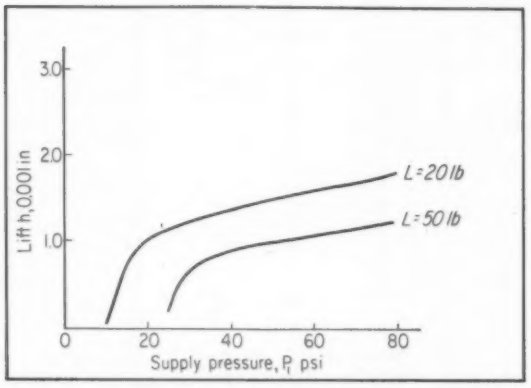

Fig. 8—Effect of supply pressure changes on lift under fixed loads for two different loads. Relationship is linear and gradient about the same for both loads.

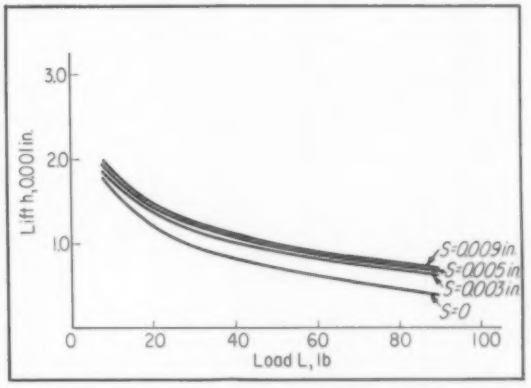

Fig. 9—Lift vs load curves for different orifice set-backs, and using a ½ in. orifice plug. Curves are similar to Fig. 2 where a ¼ in. orifice plug is used.

impossible to determine whether plug size effects the load capacity area of set-back, as shown in Fig. 9, does not greatly affect lift or stiffness.

CONCLUSIONS

It appears that the load-bearing capacity is not affected to any appreciable degree by orifice diameter, but adequate orifice set-back is required to obtain maximum load capacity. Apart from this, load-bearing capacity is only affected by bearing area and supply pressure.

Bearing stiffness is independent of orifice set-back or supply pressure for a given load, but does depend on orifice diameter. Stiffness is a maximum at minimum orifice diameter. The effect of change in bearing area on stiffness seems to be slight and depends on load.

REFERENCE:
Design Data for Flat Air Bearings by H. L. Wunsch, Mechanical Engineer, Mechanical Engineering Research Laboratory, East Kilbride, Glasgow. Published in Metalworking Production, Sept 26, 1958, p 1697-1704.

Stress and Stiffness Nomograms

From: Power

Stress developed in a spring by an applied load can be determined from Fig. 1. Corrected fiber stress in psi is determined from $S_K = 8WDK/d^3$ where W = applied load, lb; D = mean diameter of spring, in.; d = wire or rod diameter, in., or gage number; K = Wahl fiber stress correction factor based upon:

$$K = 4(D/d) - 1/4(D/d) - 4 + 0.615/(D/d)$$

Example: Spring has $D = 1\frac{3}{8}$ in.; d = 5-0 gage; W = 100 lb; find the spring stress.

K is determined on a small nomogram by joining $1\frac{3}{8}$ in. on D scale to 5-0 on d scale and equals 1.43. On main nomogram join $1\frac{3}{8}$ in. on D scale to 5-0 on d scale to intersect C scale. Join this point to 100 on W scale and project to find 5200 psi on S scale. Join 5200 psi and 1.43 on K scale to determine maximum fiber stress of 7460 lb/sq in. on S_K scale.

Spring stiffness is determined from $p = W/F = Gd^4/8ND^3$ where p = spring stiffness, lb/in. of deflection;

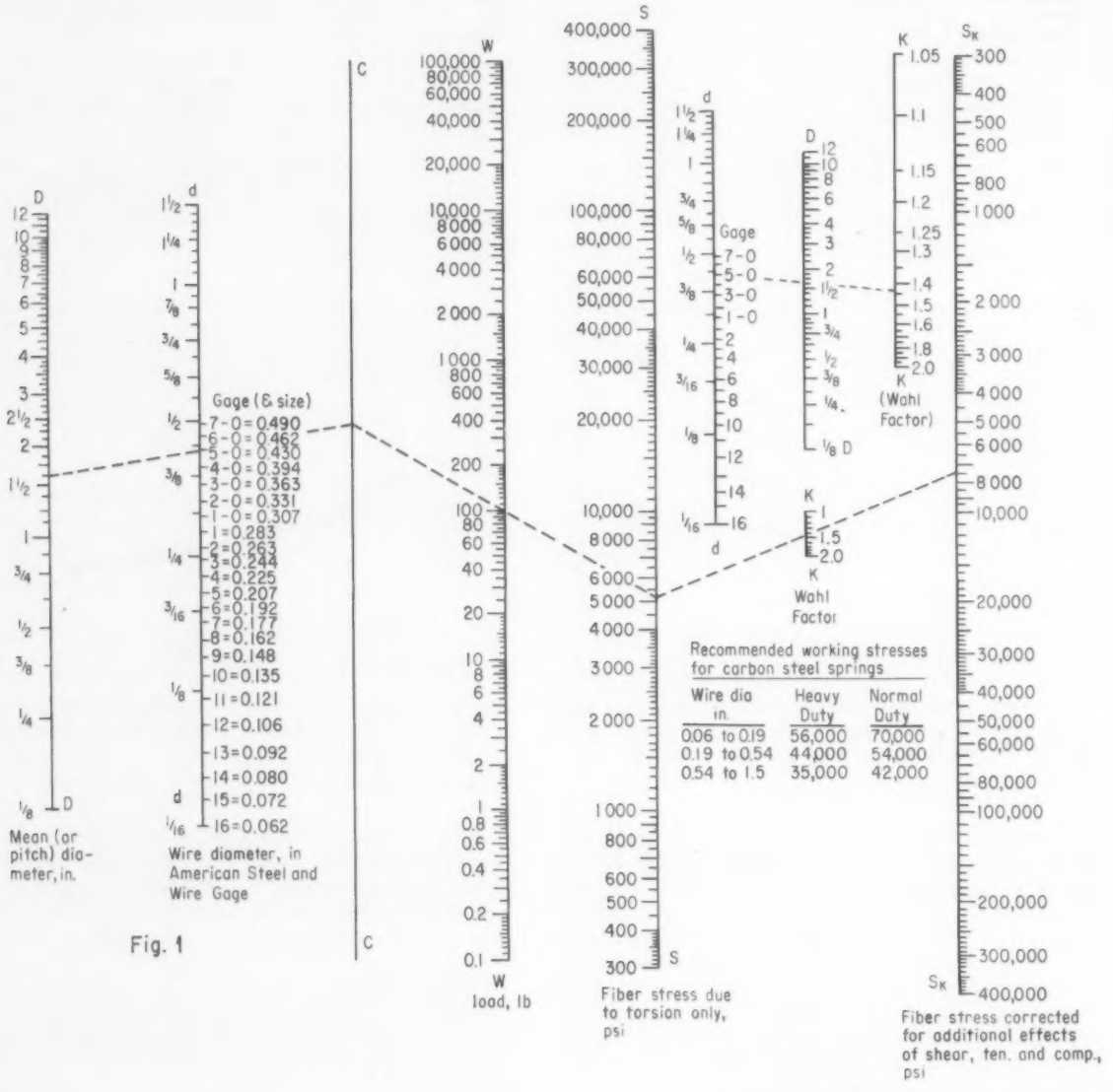

Fig. 1

for Helical Springs

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F = total deflection, in.; G = torsional modulus of elasticity, psi; N = number of effective coils.

For compression springs with closed end coils, N is two less than the apparent number of coils. For good practice D/d should be greater than 3. Example: For a spring with $G = 10 \times 10^6$ psi, p = 1000 lb/in., d = 5-0 gage, D = $1\frac{3}{8}$ in., find number of effective coils needed and the deflection when spring is supporting a 100 lb load.

Join 1000 on p scale to 10 on G scale; project to find X_1 on C_2 scale. Join 5-0 gage on d scale to $1\frac{3}{8}$ in. on D scale; project to find X_2 on C_1 scale. Join X_2 to X_1 to find 10 on N scale. Join 1000 on p scale to 100 on W scale to find F of 0.1 in.

REFERENCE:

Helical Springs Made of Round Wire or Rod—1 and 2, by J. F. Waters, Westerham, Kent, England. Published in Power, Data Sheet 315 and 316, November and December 1958, p 101 and 113 respectively.

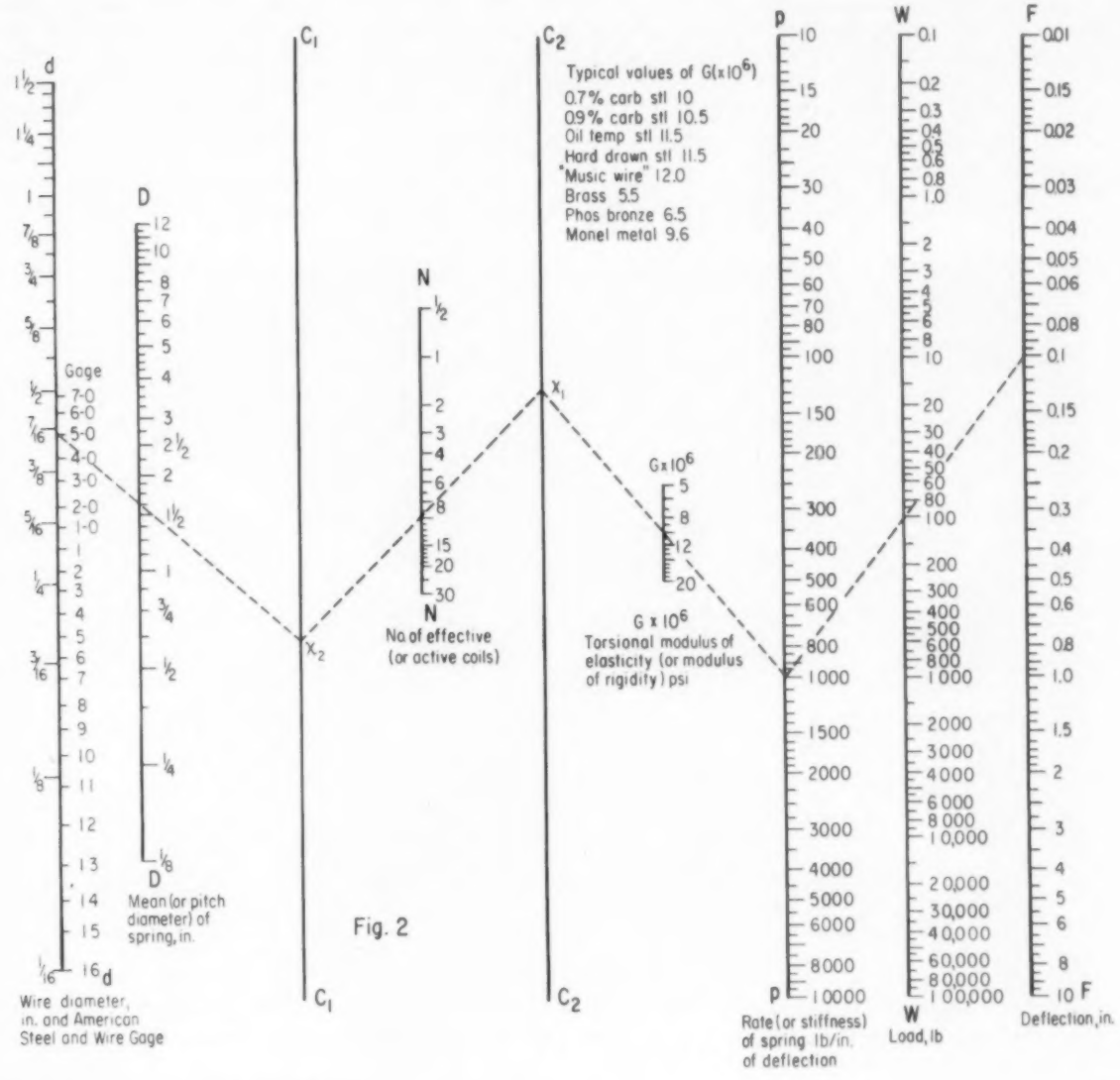

Fig. 2

From: American Machinist

Dimensional Change With Temperature

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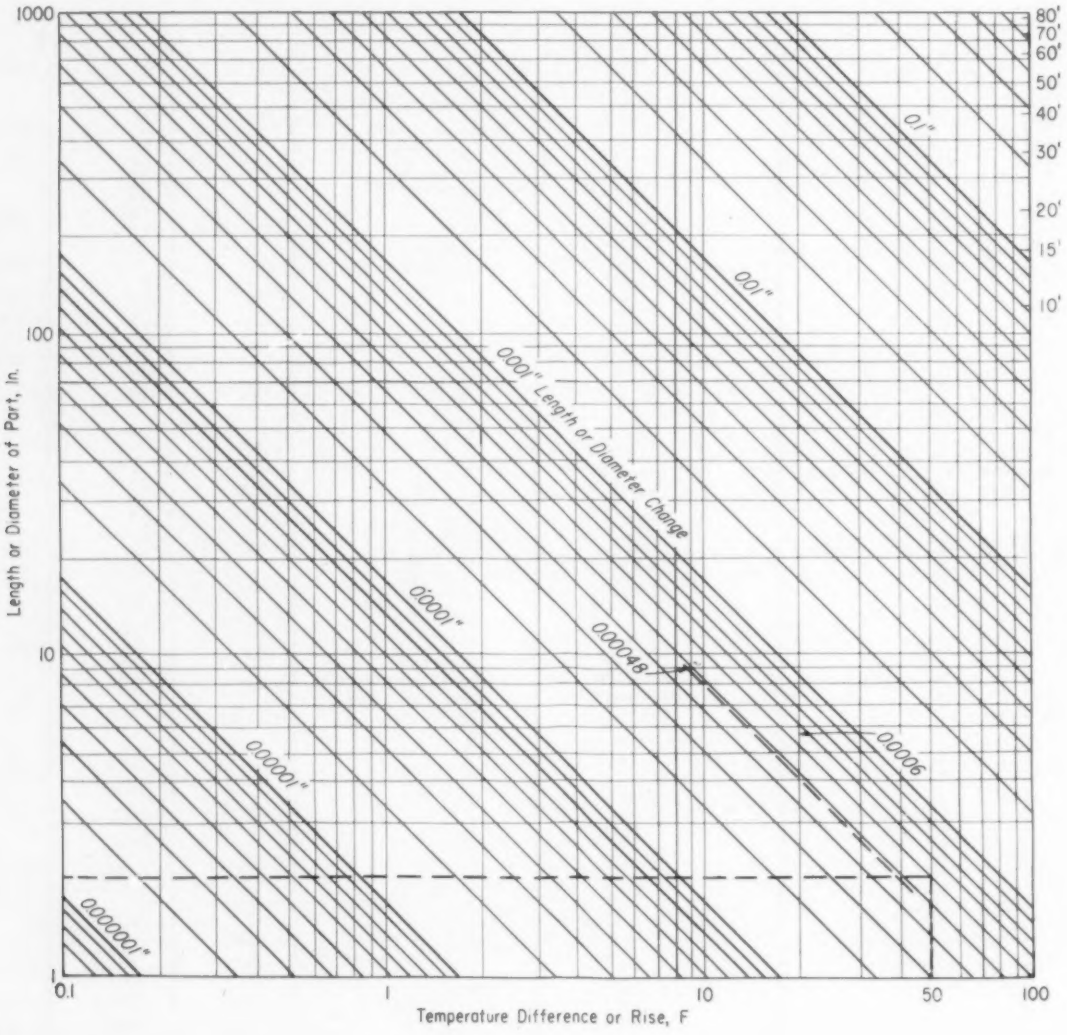
Chart is based on the expansion or contraction of soft steel which has an approximate coefficient of expansion of 0.000006 in. per inch of length or diameter per degree Fahrenheit temperature change.

For metals other than steel, a multiplier will give the dimensional change of the part. These factors are: 2.13 for al; 1.67 for br; and 2.38 for mg. Example: A 2 in. steel shaft is operating in a bronze bearing. Temperature rise for the shaft is 50 F; for the bearing 40 F. Find expansion of shaft and bearing under running conditions.

Solution: From 2 in. dia at left of chart move horizontally to intersection with 50 F line. Intersection with the diagonal line is 0.0006 in. expansion for the steel shaft. The 40 F bearing temperature rise intersects a diagonal at 0.00048 in. Multiplying by 1.67 for bronze the actual bearing expansion is 0.0008 in. Shaft will not bind in bearing because of heat rise or temperature difference.



REFERENCE:
Dimensional Change With Temperature by Charles Tiplitz, Chief Engineer, Chalon Consulting Engineers, Cedar Grove, N. J. Published in *American Machinist*, Nov. 3, 1958, p 123.

Isolation Efficiency Curve for Flexible Mounting Systems

From: Company Bulletin

For simple linear vibration, the curves illustrate the percentage of vibration isolation it is possible to obtain in a flexibly mounted assembly with any combination of static deflection and disturbing frequencies.

The lower area shows the region of magnification that occurs when the ratio of the disturbing frequency to the natural frequency of the mounted assembly is less than $\sqrt{2}$. A condition of resonance exists when the natural frequency of the assembly and the disturbing frequency are equal.

The upper area shows the percentage of the vibratory forces prevented from reaching the supporting structure when proper flexible mountings are selected. Reduction in transfer of vibratory forces is obtained only when the ratio of the disturbing frequency to the natural frequency is greater than $\sqrt{2}$.

Decibel term, as used on this curve, is mathematically expressed by the equation

$$db = 20 \operatorname{Log}_{10} A_0/A_1$$

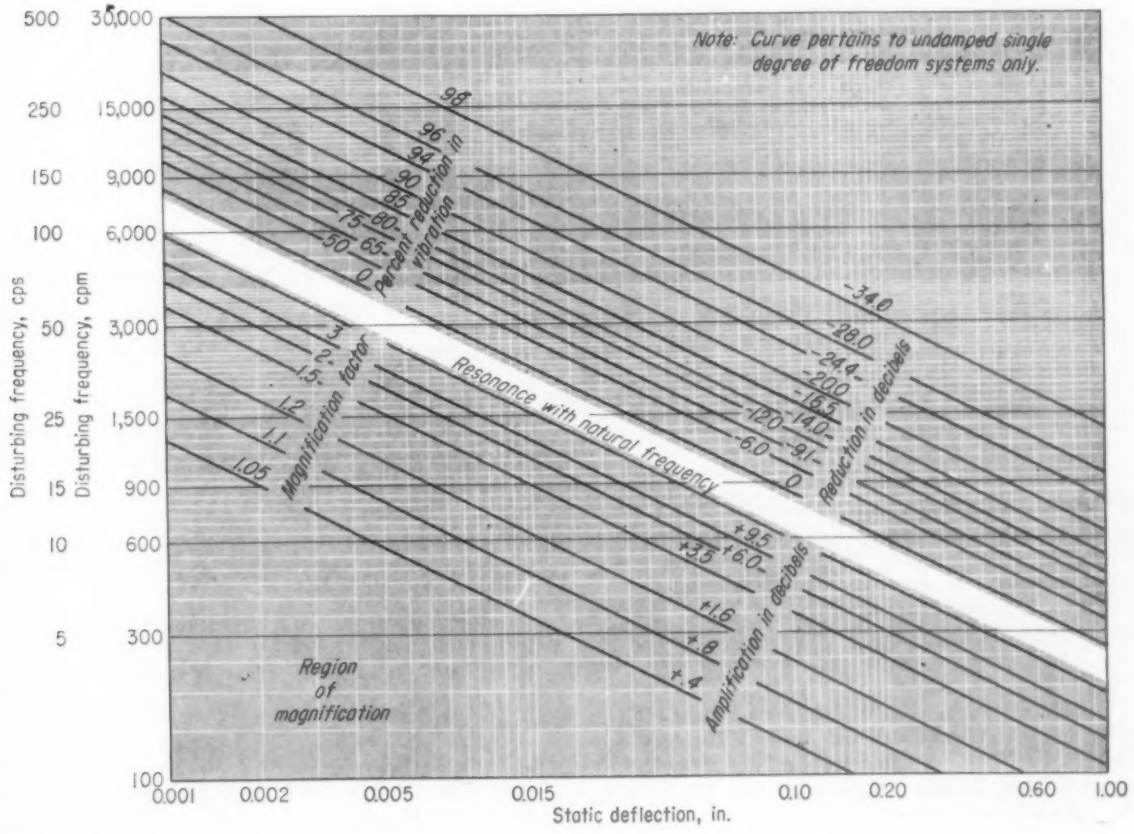
where A_0 is the amplitude of the mounted mass and A_1 is the amplitude of the disturbing frequency.

Example:

To determine the static deflection required for a desired per cent reduction in vibration:

1. Enter chart along the vertical axis at the known disturbing frequency of the system.
2. Follow the horizontal line representing the disturbing frequency until it intersects a diagonal line representing the desired per cent reduction in system vibration.
3. A vertical line from the point of intersection to the base axis will indicate the static deflection required.
4. Since static deflection equals weight/spring rate, the required spring weight can be readily calculated.

REFERENCE:
Isolation Efficiency Curve, Bulletin No. 901. Published by Lord Manufacturing Company, Erie, Pennsylvania.



Symmetrical Bending of Circular Plates

General elastic equations for the radial and tangential bending moments—hence stresses—are derived for a circular plate with a circular hole at the center loaded with a uniform pressure and simply supported along the inner and outer boundaries. Comparison is made for the maximum radial bending moments of the design analyzed with two other designs.

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Space Flight Division
Bell Aircraft Corporation

NOMENCLATURE

- p = Pressure, psi
- a = Outer radius of plate, in.
- b = Inner radius of plate, in.
- r = Radius measure from center of plate, in.
- h = Thickness of plate, in.
- w = Deflection, in.
- M_r = Radial moment
- M_t = Tangential moment
- Q = Shearing force per unit length of a circumference of radius, r
- P = Total shearing force at the inner boundary of the plate
- D = Flexural rigidity of a plate = $\frac{Eh^3}{12(1-\mu^2)}$
- E = Young's modulus
- μ = Poisson's ratio
- σ_r = Radial stress, psi
- σ_t = Tangential stress, psi

Pressure vessel design requires methods of analysis of circular plates under uniform pressure with various edge conditions. Timoshenko's "Theory of Plates and Shells" gives max stress for different edge conditions.

There is, however, a frequently met design which is not derived. This is a circular plate with a hole in the center under uniform pressure and simply supported along the inner and outer edges.

Solution is by superposition using Case 7 and Case 1 as given in "Theory of Plates and Shells." The maximum deflection of Case 7 is found and then the shearing force along the inner boundary of Case 1 is calculated to bring the deflection back to zero.

Deflection equations for Case 7 and 1 are:

$$W_{max} = k_1\,(7)\,(pa^4/Eh^3) \quad (1)$$

$$W_{max} = k_1\,(1)\,(Pa^2/Eh^3) \quad (2)$$

Equating (1) and (2), gives

$$P = [k_1\,(7)/k_1\,(1)]\,pa^2 \quad (3)$$

Let $K = k_1(7)/k_1(1)$, then

$$P = Kpa^2 \quad (3a)$$

The general expression for shear, Q is

$$Q = 1/2\,\pi\,r\,[\pi\,p(r^2 - b^2) - Kpa^2]$$
$$= pr/2 - p/2r\,[b^2 + (Ka^2/\pi)] \quad (4)$$

Let $A = P/2$ and $B = p/a\,[b^2 + (Ka^2/\pi)]$, then

$$Q = Ar - B/r \quad (4a)$$

The radial moment, M_r, at a point distant, r, from the center of the plate is

$$M_r = D(d^2w/dr^2 + (\mu/r)\,dw/dr] \quad (5)$$

and the tangential moment, M_t is

$$M_t = D\,(r1/r)\,dw/dr + \mu\,d^2w/dr^2] \quad (6)$$

The expressions for dw/dr and d^2w/dr^2 can be determined from the following

$$d/dr = [(1/r)\,d/dr + r\,dw/dr] = Q/D \quad (7)$$

Substituting Eq (4a) into (7) and integrating twice, gives

$$dw/dr = 1/D\,[Ar^3/8 + (Br/2)\ln r + Br/4 + C_1r/2 + C_2/r] \quad (8)$$

Differentiating Eq (8) gives

$$d^2w/dr^2 = 1/D\,[3Ar^2/8 - B/4 - (B/2)\ln r + C_1/2 + C_2/r^2] \quad (9)$$

Substituting Eqs (8) and (9) into Eqs (5) and (6)

$$M_r = (Ar^2/8)\,(3+\mu) - (B/4)\,(1-\mu) - B/2\,(1+\mu)\ln r + (C_1/2)\,(1+\mu) - (C_2/r^2)\,(1-\mu) \quad (10)$$

The two constants, C_1 and C_2, are determined by the boundary conditions such that the radial bending moments at both the inner and outer boundaries are zero. With these constants determined, the final generalized equations for M_r and M_t are

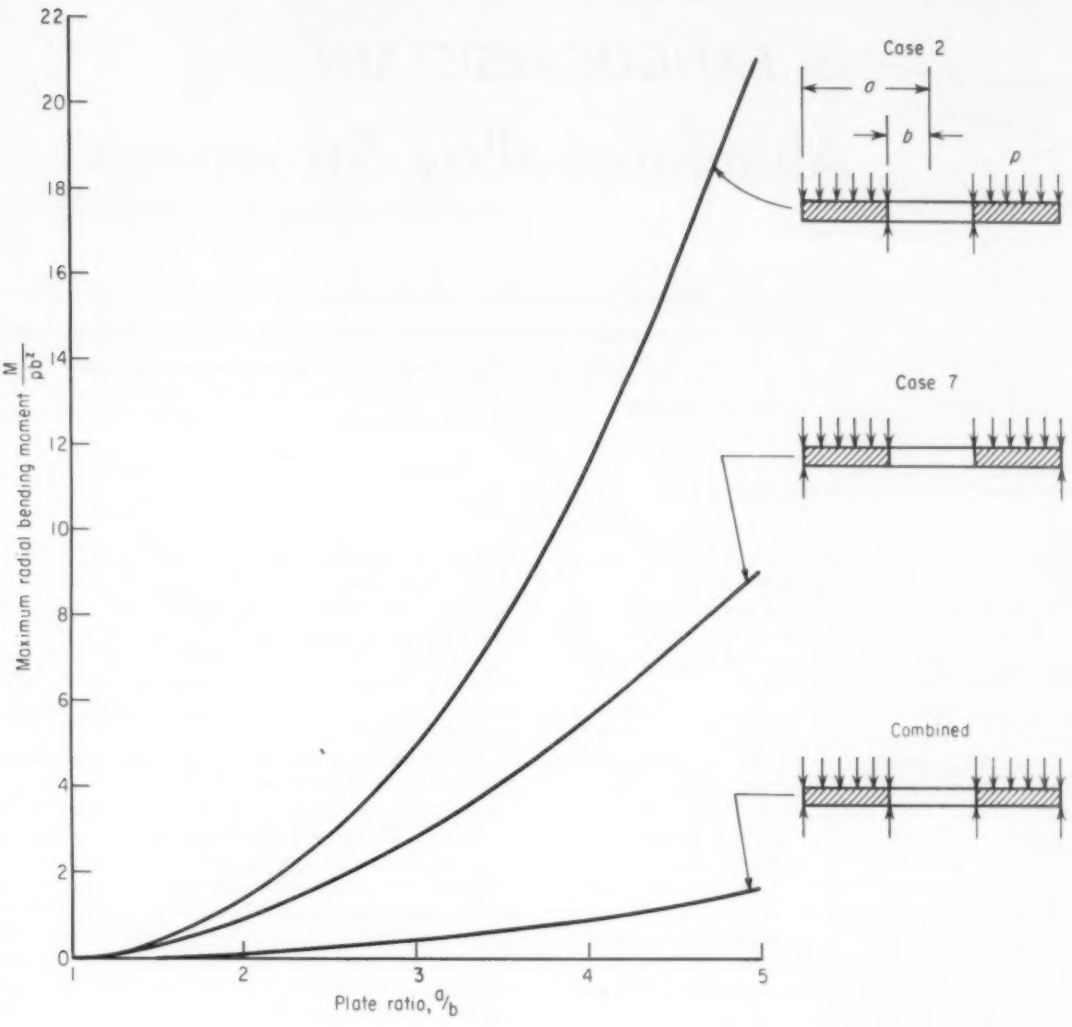

Fig.1

Fig. 1—Maximum radial bending moment vs plate ratio for Case 2 and Case 7 from "Theory of Plates and Shells." Design analyzed shows much lower values than designs where uniform pressure is simply supported along either the inner or outer circle. Poisson's ratio for all three designs is 0.30.

$$M_r = [A\,(3+\mu)/8]\,[r^2 + (a^2b^2/r^2) - (a^2+b^2)] + (B/2)\,(1+\mu)\ln a/r + \left\{[Bb^2\,(1+\mu)\ln a/b]/[2(b^2-a^2)]\right\}[(a^2/r^2)-1] \quad (12)$$

$$M_t = [Ar^2\,(1+3\mu)/8] - [A\,(3+u)/8]\,[a^2+b^2+(a^2b^2/r^2)] + B/2\,[1-\mu+(1+u)\ln a/r] - \left\{[Bb^2\,(1+u)\ln a/b]/[2\,(b^2-a^2)]\right\}[(a^2r^2+1)] \quad (13)$$

For $\mu = 0.30$, Eqs (12) and (13) reduce to

$$M_r = 0.413\,A[r^2 + (a^2b^2/r^2) - (a^2+b^2) + 0.65\,B\ln a/r + [(0.65\,Bb^2\ln a/b)/(b^2-a^2)]\,[(a^2/r^2)-1] \quad (14)$$

$$M_t = 0.238\,Ar^2 - 0.413\,A\,[a^2+b^2+(a^2b^2/r^2)] + B(0.35+0.65\ln a/r) - [(0.65Bb^2\ln a/b)/(b^2-a^2)]\,[(a^2/b^2+1)] \quad (15)$$

Bending stresses are given by the following equations:

$$\sigma_r = \pm 6\,Mr/h^2 \text{ and } \sigma_t = \pm 6M_t/h^2$$

Maximum radial bending moment for the design analyzed is plotted, Fig. 1, using a value of 0.30. For comparison, a uniform pressure, simple supported along the inner circle, and a uniform pressure, simply supported along the outer circle, are shown.

BIBLIOGRAPHY:

Theory of Plates and Shells by S. Timoshenko, McGraw-Hill Book Company, 1940, First Edition.

From: Aero/Space Engineering

THIN DOUBLERS for FATIGUE-RESISTANT Aluminum-alloy Structures

Titanium and stainless steel doublers can reduce high bending stresses by engaging an extra row of rivets outside the main splice. Problem is bimetallic corrosion. Gains are higher fatigue life and fail-safe feature.

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Convair-San Diego, A Div of General Dynamics Corp

Structures free of fatigue problems are difficult to design, especially in aircraft. A fatigue-free design incurs a large weight penalty; in many designs a penalty that cannot be afforded. The alternative is to design structures that permit a certain amount of fatigue cracking without endangering safety. This is fail-safe design.

Fail-safe design sets up multiple paths of loading so that complete failure could occur along one path without complete loss of the assembly. Fail-safe load as recognized in the aircraft industry is 53% of the design ultimate load.

Fatigue strength of a typical riveted joint can be increased over 20% by driving rivets through the edges of a splice doubler. Joint life is correspondingly increased between five and ten times. Purpose of the edge-driven rivets is to relieve the loaded rivet from bending stresses.

A corollory to this would be to allow bending to take place at the first rivet—but to reduce the total stress before it got to the first rivet by use of a thin doubler. Extending beyond this splice, an extra rivet or row of rivets is driven through the doubler and skin only. The doubler would have to be thin enough to minimize bending stresses at the auxiliary rivets, yet strong enough to reduce the loads going into the main splice of the structure.

FATIGUE AND STATIC TEST PROGRAM

Butt joints of 2024-T3 aluminum alloy, Fig. 1(A), using a 2024-T3 extrusion T section as a splice plate were prepared. Three $\frac{1}{4}$ in. dia, 100° countersunk 2024-T rivets were set 1 in. apart on each side of the splice.

Two additional sets of specimens were modified by inserting an 0.020 in. thick $\frac{1}{2}$ hard, Type 302 stainless steel or 6AL-4V titanium doubler in the faying surfaces. Doubler extends beyond the extrusion, Fig. 1(B), to permit the extra rivet to be added. Stainless steel doublers were cadmium plated and the titanium doublers had a special corrosion treatment.

All specimens were loaded axially in the fatigue testing machine, using a stress ratio of 0.10 for all tests. Approximately 4 specimens at each stress level were used to determine log mean values for plotting the S-N curves. Additional specimens were exposed to a salt spray test.

Two large 5 in. wide specimens of each type—using 0.020 in., 2024-T3 doublers—were also tested. These, however, were loaded at a nominal gross stress of 10,500 psi with a 0.16 stress ratio.

The extrusions in two of the 5 in. wide specimens and four of the small specimens were sawed in two along the innermost line of rivets, leaving only the doubler holding to the skin. These were cycled at 10,000 psi nominal gross stress until failure occurred.

A third type of specimen—not representative of a fail-safe structure—was prepared in the form of a butt joint $1\frac{1}{4}$ in. wide by 0.064 in. thick of 7075-T6 alloy with a 0.020 in. stainless steel doubler. Purpose: to determine whether a steel doubler could avert the need for joggling. Additional specimens were modified by driving rivets through the edges of the doubler so that the center of the rivet fell in line with the edge of the doubler.

To obtain allowable data for static design on stainless steel doublers, lap joints of 0.064 in. aluminum to 0.020 in. stainless steel were made. Yield strength for the purpose of the program was 0.005 in. permanent set across the joint of the specimens.

FATIGUE AND STATIC TEST RESULTS

Results of fatigue tests on 1 in. wide butt joints with extrusion splice plates are shown in Fig. 2. Points represent the log mean life of a number of specimens. Ordinates are for nominal gross stress in the aluminum sheet away from the splice area.

The thin doubler curve represents both stainless steel and titanium, with no apparent difference in fatigue life between the two. Many times, failure occurred through the combined extrusion and steel doubler.

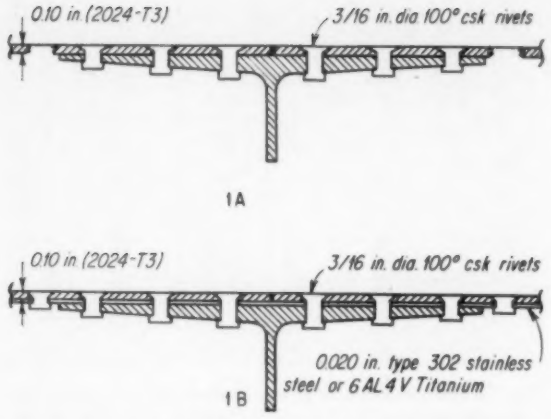
0.10 in. (2024-T3)
3/16 in. dia. 100° csk rivets
1A
0.10 in. (2024-T3)
3/16 in. dia. 100° csk rivets
0.020 in. type 302 stainless steel or 6 AL 4 V Titanium
1B

Fig. 1—Specimens for fatigue and static tests. (A) Control specimen which represents a typical aircraft structure. (B) Specimen with doubler and extra rivet added. Structure lends itself to fail-safe design if doubler strength alone is sufficient to carry the load.

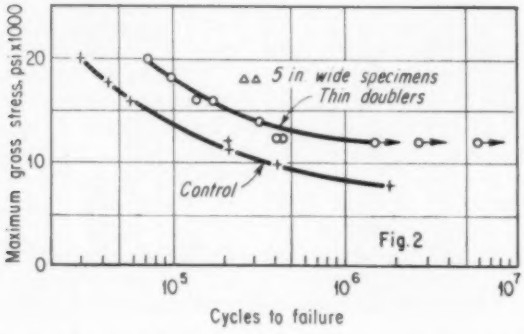

Fig. 2—Cycles to failure vs maximum gross stress for butt joints with doublers. Thickness combination used are arbitrarily chosen to induce failures in the doubler region so that time elapse between extrusion and doubler failure could be observed. Doubler failures at high stress level loading were immediately followed by final failure of the butt joint.

Salt spray fatigue data are not complete. However, available data indicates no change in life for either the control or test specimens.

The control for the 5 in. wide specimens failed after 676,000 and 717,000 cycles. Two specimens with steel auxiliary doublers did not break after ten million cycles. Tests were stopped and the load raised to 18,000 psi, from 10,000 psi, whereupon failure occurred after an additional 269,000 and 301,000 cycles.

Two 5 in. wide specimens with 0.020 aluminum alloy doublers failed after 3,674,000 and 4,220,000 cycles. The 5 in. wide sawed extrusion specimen failed after 20,000 cycles. Two 1 in. wide sawed extrusion specimens failed after 182,000 and 106,000 cycles.

Fatigue test results for the 1¼ in. wide butt joints with steel doublers are shown in Fig. 3. All failures occurred through the first rivet in the control specimens. However, where edge rivets were used in steel doublers, the failures

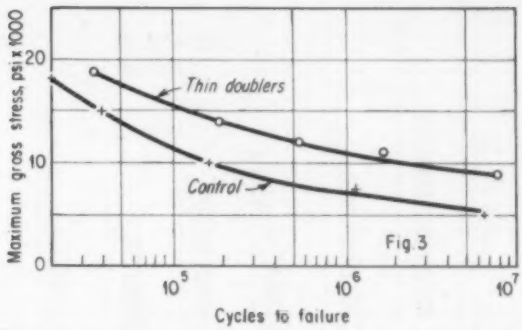

Fig. 3—Cycles to failure vs maximum gross stress for 1¼ in. wide butt joints. Lower curve represents a conventional splice with equal thickness aluminum doubler. Upper curve is for 0.020 steel doubler with edge driven rivets. Joint is designed with eight rivets—four on each side of the splice, including the edge rivet. All failures occurred through the first rivet in the control joint; random failures were recorded in the doubler joint.

TABLE I—Yield Strength Per Rivet

	Yield, Lb	Adjusted Yield, (1) Lb	Ultimate Lb
Control	1,360		2,330
	1,410		2,280
Steel	1,120	890	1,325
Doubler	1,150	850	1,280

(1) Adjusted to 66.7 per cent of the ultimate failing load. This was not necessary for the control because the 0.005-in. slip load was less than this value.

for high level loading occurred through the edge rivet; low level loading produced cracks at many locations—as many as five out of eight rivet locations. In some instances, failure took place through one of the middle rivets.

Table I shows the results of the static tests for strength per rivet in the steel and doubler.

TEST CONCLUSIONS

It appears that added fatigue strength or weight-saving can be achieved by using thin auxiliary doublers of high-strength material in an aluminum-alloy structure.

While the improvements shown are substantial, they are not optimum. Advances indicate that structures may be designed in the future in which fatigue will not be a problem.

The effective concentration factor for these specimens was about 3. That for a rivet-filled hole is between 1.2 and 1.5. Hence, the next step toward designing fatigue resistant structures would be to approximate the fatigue strength of rivet-filled holes; this could be done mechanically. Further improvements will probably depend on adhesive bonding, in addition to proper proportioning of doubler to skin thickness.

REFERENCE:
Thin Doublers for Fatigue-Resistant Aluminum-alloy Structures by C. R. Smith, Design Specialist, Convair-San Diego, A Division of General Dynamics Corporation, San Diego, California. Presented at the 1959 IAS Annual Meeting, New York, and published in Aero/Space Engineering, February, 1959, p 40-42.

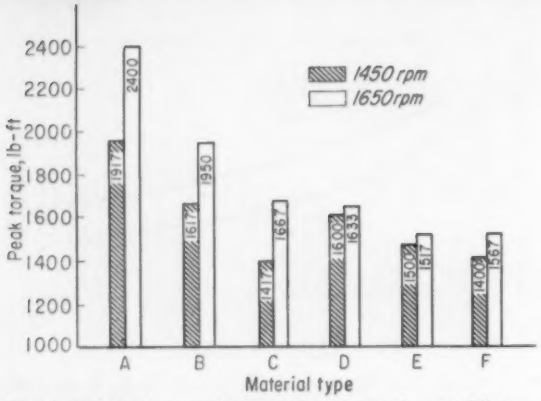

Fig. 1—Relative torque characteristics of ceramic materials for snap engagement of a 13 in. dia single plate over-center clutch.

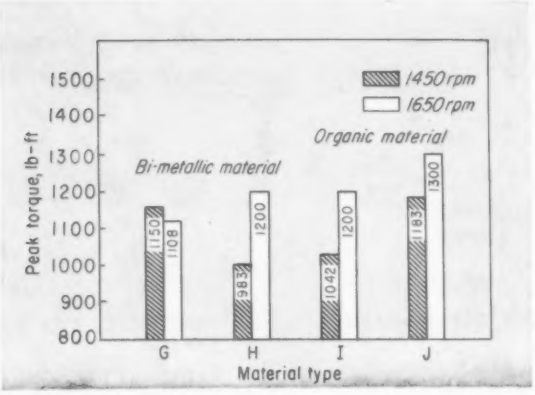

Fig. 2—Relative torque characteristics of various materials for snap engagement of a 13 in. dia single plate over-center clutch.

From: SAE paper

Dry Clutch Torque Evaluation

Test data show behavior of ceramic, bi-metallic and organic friction materials. Also, peak torque values during clutch engagements and values when a torque converter is used.

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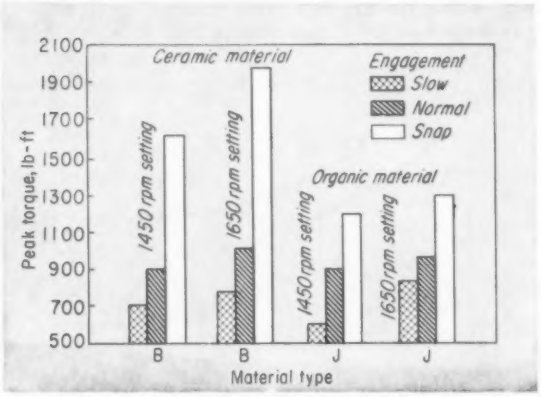

Fig. 3—Peak torque values obtained by varying engagement procedure using a 13 in. dia single plate over-center clutch.

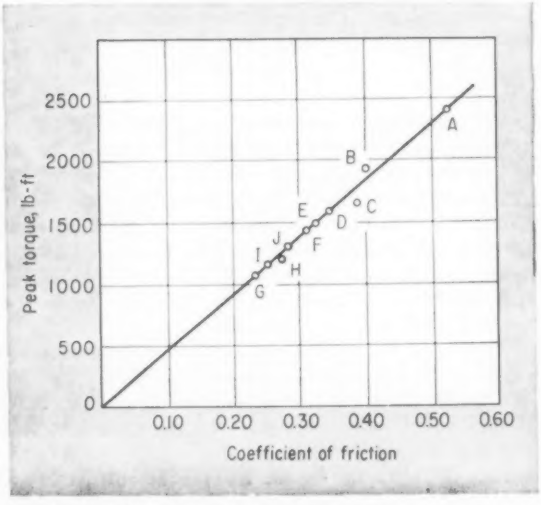

Fig. 4—Peak torque values vs coefficient of friction for a 13 in. dia single plate over-center clutch.

A vital link in the power transmission circuit of heavy duty machines is the engine clutch. By virtue of its position the clutch is directly influenced by certain engine characteristics and, in turn, its behavior reflects in various ways on the performance acceptability of the entire machine.

A study of dry type clutches was made directed primarily towards the engagement characteristics. Considerable information was obtained regarding the relative behavior of ceramic, bi-metallic, and organic friction materials in engine clutch applications and peak torque values obtained during clutch engagement.

TEST RESUTS

Peak torque characteristics of a number of ceramic, bi-metallic, and organic materials are shown in Figs. 1 and

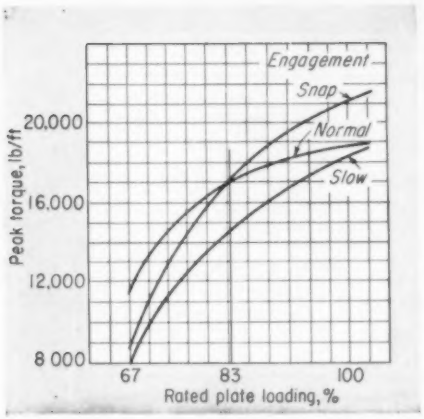

Fig. 5—Effect of plate loading on peak torque values for a 17 in. dia spring loaded clutch for various clutch engagements.

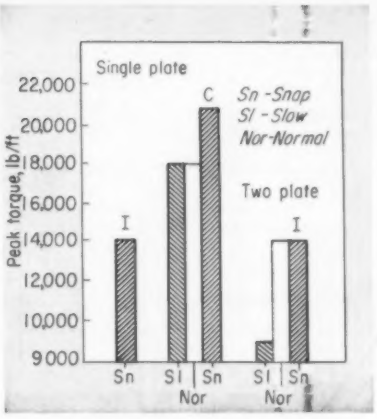

Fig. 6—Behavior of single and two plate clutches using a ceramic and an organic material for various engagements.

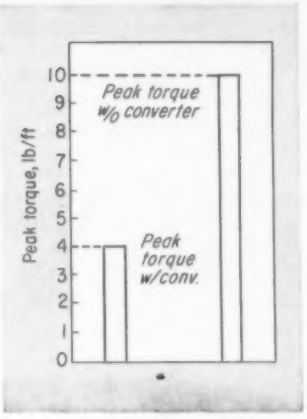

Fig. 7—Effect of torque converter on clutch peak torque values. Torque reduced to 4 lb/ft.

2. Ceramic materials offer a wide range of values, and these values are all above the peak values given by the bimetallic or organic materials.

Clutch engagement bears directly on the shock loads imposed on the components of a machine. Fig. 3 indicates some interesting points, for example, snap engagements develop high peak torques.

The relationship of torque to coefficient of friction, Fig. 4, is highly useful in determining material selection for a given application. This information combined with field performance data permits, within a narrow range, a material to be selected based on its coefficient of friction for a given application.

In many applications, the use of a spring loaded clutch is preferred. Desirable peak torque characteristics are easier to attain since it is possible to change the spring loading. Fig. 5 shows the effect of plate loading on peak torque values for a spring loaded clutch. However, the same friction material properties are important.

Comparative results of an organic and ceramic material 17 in. dia single plate clutch are shown in Fig. 6. The same relationship between materials exists for spring loaded and over-center clutches. Materials behave in the same manner for a 15½ in. dia two plate clutch designed for the same capacity.

In addition to the dynamic tests, static tests were made of certain materials. Fig. 8 shows the values of the break-away and peak torques.

A clutch used in a torque converter drive will record lower peak torque values. To determine the reduction an engine with a total WR^2 of 25,318 lb-in.^{2} including the clutch was used. A 17 in. dia over-center type clutch was used to couple the engine to a three-stage converter with a specific torque rating of 439 lb-ft. Fig. 7 shows the shock absorbing effect of the torque converter. With snap engagement, the clutch slipped 0.5 rev while engine speed dropped from 1630 to 1460 rpm in 0.6 sec.

Additional tests showed that it was possible to meet clutch shaft peak torque values ranging from 4 to 5 times

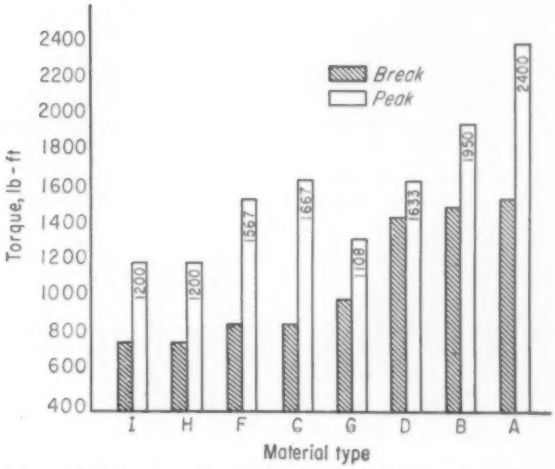

Fig. 8—Relationship of peak to static break-away torque for a 13 in. dia single plate over-center clutch.

the rated engine torque with organic materials and up to 10 to 12 times engine torque with some ceramic materials. The difference is attributed to: (1) ceramic materials have a higher coefficient of friction; and (2) ceramic materials are less susceptible to the affects of heat.

CONCLUSION

Although the data regarding peak torque characteristics are important, it is not the sole basis for judging the acceptability of a given friction material. The material must be evaluated from the standpoint of wear rate, smoothness of engagement, relative cost, and other factors.

REFERENCE:

Dry Clutch Torque Evaluation by J. R. Prosek and H. M. Barber, International Harvester Company, Chicago, Illinois. Presented at SAE National Farm, Construction, and Industrial Machinery Meeting, Milwaukee, Sep '58. Paper No. 76A.

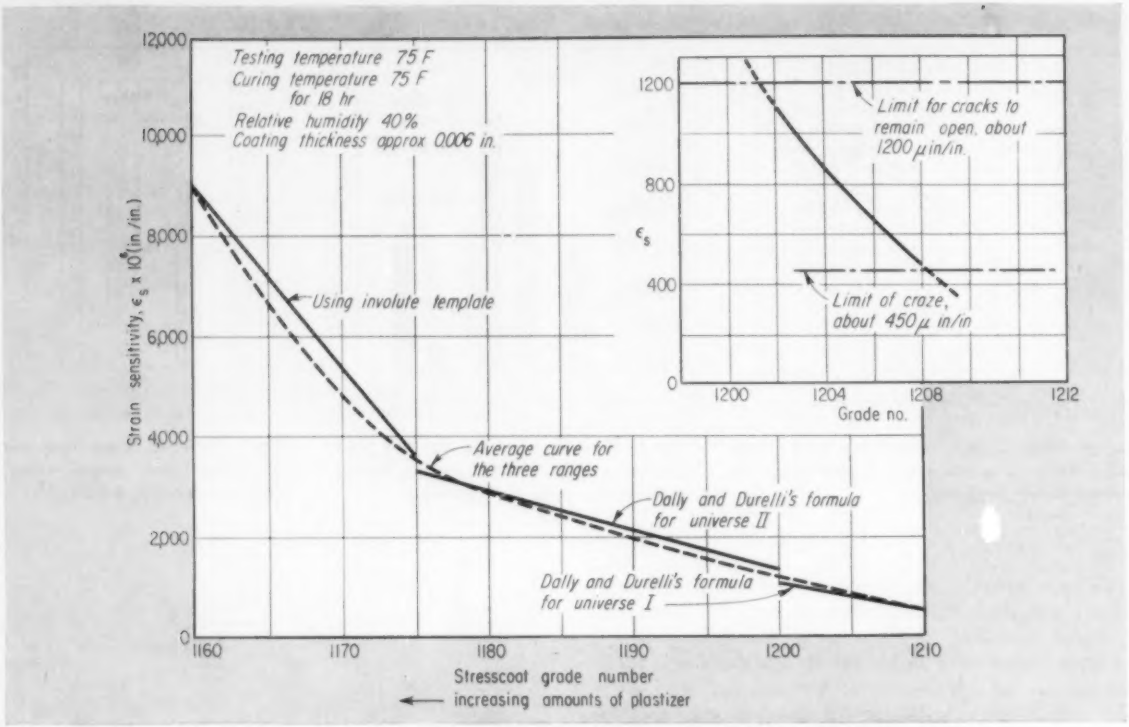
Testing temperature 75 F
Curing temperature 75 F for 18 hr
Relative humidity 40%
Coating thickness approx 0.006 in.
Using involute template
Average curve for the three ranges
Dally and Durelli's formula for universe II
Dally and Durelli's formula for universe I
Strain sensitivity, ϵ_s x 10^6 (in./in.)
Stresscoat grade number
increasing amounts of plastizer
Limit for cracks to remain open, about 1200 μin/in.
Limit of craze, about 450 μ in/in
Grade no.

Fig. 1—Influence of grade on strain sensitivity. Atmospheric conditions, coating thickness, and curing conditions are all specified as a variance in these will vary the strain sensitivity. Curve can be used to select a grade for a given strain sensitivity.

Variables Affecting Brittle Coating in Stress Analysis

Six variables influence the behavior of the coating; composition, curing, thickness, atmospheric conditions, load-time relation, and stress biaxiality. Relationship of each is shown to the brittle coating test procedure.

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A. J. DURELLI
Armour Research Foundation
Illinois Institute of Technology

The brittle coating method of experimental stress analysis gives a simple and direct approach to the solution of many problems. The method is based on the adhesion of a brittle coating to a part to be analyzed and on the failure of this coating at a stress level lower than the stress required to fail the component.

Advantages and limitations of the method are discussed in Table I. The behavior of the coating may be characterized by its strain sensitivity (ϵ_s) which is the minimum strain required to crack the coating in an uniaxial state of stress. There are many variables that influence the behavior of the coating; the six most important are: (1) coating composition; (2) curing; (3) coating thickness; (4) atmospheric conditions during test; (5) load-time function; and (6) biaxiality of the stress field.

COMPOSITION OF THE COATING

Coating, as received from a manufacturer, consists of about ½ natural

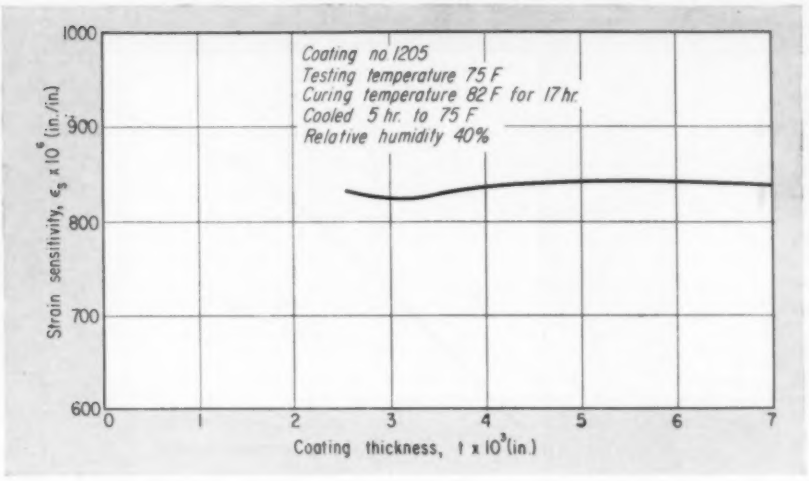

Fig. 2—Strain sensitivity vs thickness. Whenever possible, the brittle coating should be cured between 80-85 F to eliminate errors introduced by unavoidable thickness variations.

resin dissolved in about $\frac{2}{3}$ carbon disulfide with a small amount of plasticizer. By increasing the amount of plasticizer, the strain required to crack the coating is increased and the coating sensitivity decreased.

Amount of plasticizer is denoted by a grade number ranging from 1160 for the least sensitive to 1215 for the most sensitive coating. For most normal temperature testing a coating with a 1200-1210 range is adequate. Fig. 1 indicates the influence of grade used on the value of strain sensitivity ϵ_s.

COATING CURE AND THICKNESS

These items are interrelated in their influence on coating behavior as the time required to cure a coating depends upon temperature and humidity of the curing chamber and the thickness of the coating.

Room temperature curing—75 F and 40% humidity—produces a coating which has decreasing sensitivity with increasing thickness; high temperature curing—125 F and 5% humidity—produces a coating which has increasing sensitivity with increasing thickness. By curing at about 80 to 85 F, a coating is obtained which is insensitive to changes in coating thickness. Fig. 2 shows strain sensitivity plotted as a function of thickness.

Curing should be done in an oven or a room which has essentially a uniform temperature distribution. Fig. 3 shows the sensitivity of the coating as a function of curing temperature. To use heat lamps to obtain this moderate heat treatment can cause problems for the curing temperature of the coating varies from point to point on the component and the properties of the coating will also vary.

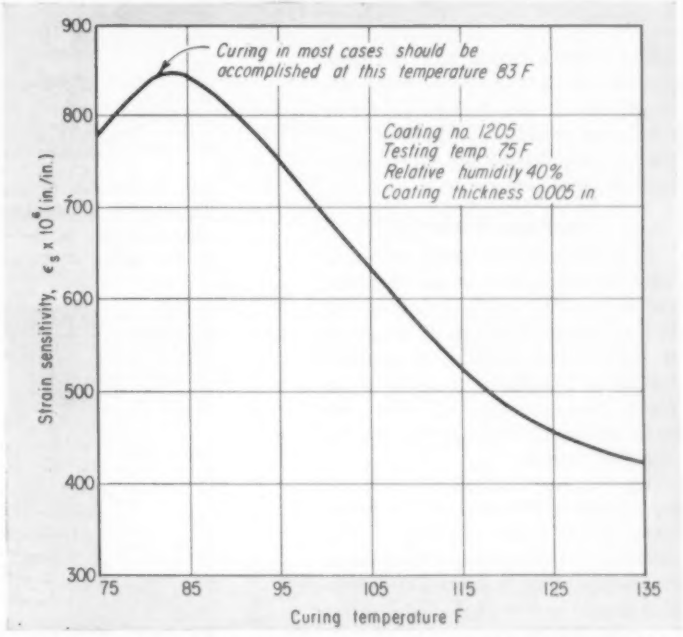

Fig. 3—Sensitivity of coating to curing temperature. Curing between 80-85 F also minimizes erratic coating behavior caused by small changes in temperature gradient in the curing chamber.

In certain instances coatings must be heat treated to obtain sensitive coatings for use on low yield base materials such as glass. Here, the coating is heated to 135 F and cooled slowly to the test temperature around 75 F. Strain sensitivity will be about 250-300 micro-in./in. One precaution: a uniform thickness coating is necessary.

The resin base coating is temperature sensitive as shown in Fig. 4. A 3 F testing temperature change will produce a change in strain sensitivity of about 100 micro-in./in. For consistently good results a temperature controlled atmosphere is required. If

TABLE I—Advantages and Limitations of Brittle Coating Method

Advantages:

1—It gives nearly whole field data for both magnitude and direction of the principal stresses and does not require a tedious point per point analysis.

2—It does not require the construction of a model and can be applied to the actual machine component being studied.

3—As a consequence of (2), often it is not necessary to simulate loading conditions.

4—Data obtained is converted to stresses in a simple fashion without elaborate and complex mathematical analysis.

Limitations:

1—Precision of the measurement varies depending upon atmospheric changes during test, thickness control, load-time history, biaxiality of the stresses and the skill with which the test is made.

field or factory testing must be done, a stable temperature part of the day should be selected, the test should be conducted as rapidly as possible, and the coating should be continuously calibrated to avoid errors.

LOAD-TIME RELATION

Calibration of the brittle coating is done by deflecting a cantilever beam, and the position of the crack nearest to the free end is noted. As the strain is known as a function of position, measuring a distance gives the strain sensitivity of the coating. Here, the strain sensitivity is dependent on the load-time relation.

The beam is deflected in less than 1 sec and held in the depressed state for about 15 sec before releasing. If the component loading cannot be done in exactly the same manner the calibration should be corrected. Fig. 5 shows the correction chart.

Dynamic stress analyses are also possible if two precautions are followed. (1) The coating must be more sensitive than for static tests to insure that the cracks remain open after loading; and (2) the correction of the static calibration to account for the duration of the load. Fig. 6 shows the influence of load duration on strain sensitivity for dynamic stress analyses.

BIAXIALITY OF THE STRESS FIELD

The most frequently used relationship for the interpretation of brittle coating data is

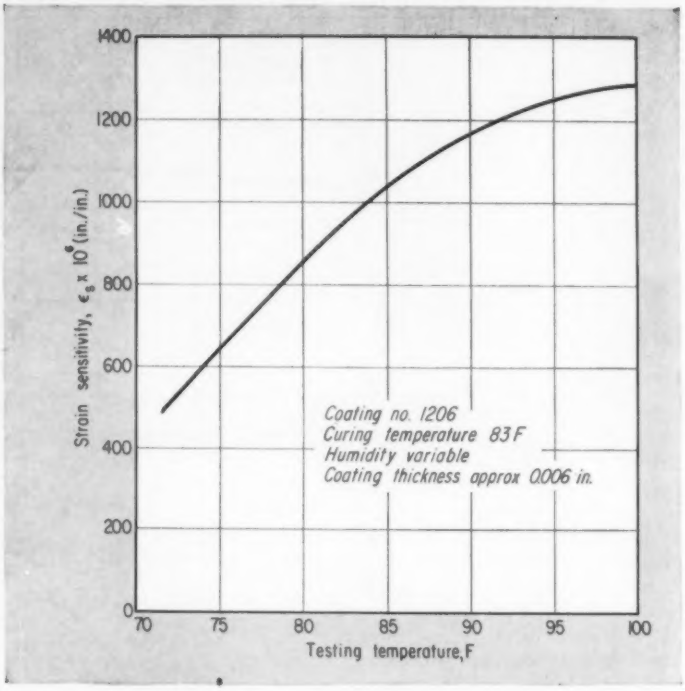

Fig. 4—Influence of testing temperature on the strain sensitivity. Strength of the coating is probably unaffected by slight temperature changes; hence the marked change in the strain required to crack the coating is probably caused by the change in the coating residual stresses when it expands or contracts.

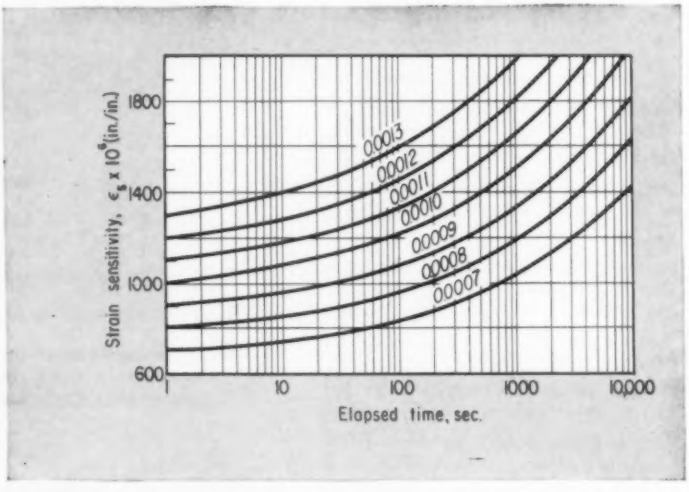

Fig. 5—Correction chart for changes in load-time relation. When the load is applied slowly the coating creeps and loses sensitivity.

$$\sigma_1 = E\epsilon_s$$

Where: σ_1 is the max principal stress, psi; E is the modulus of elasticity of the test part., psi, and ϵ_s is the calibrated strain sensitivity.

This relation totally neglects the biaxial effect of either ϵ_2 or σ_2. In calibration $\sigma_2 = 0$ and $\epsilon_2 = -\nu\epsilon_1$; however, in practice σ_2 and ϵ_2 may have any value respect to σ_1 and ϵ_1. Results

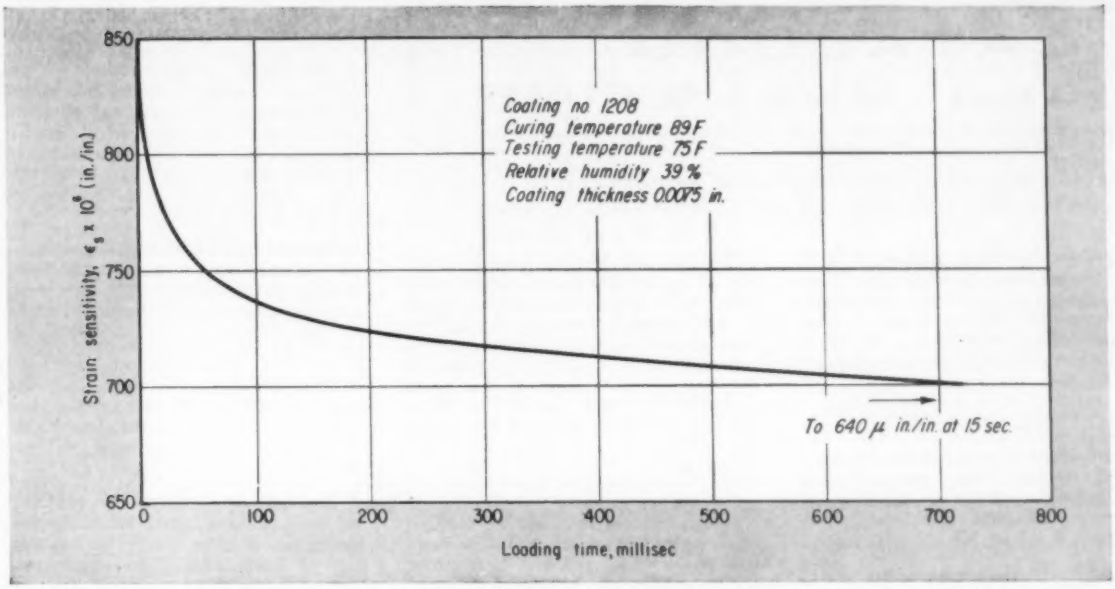

Fig. 6—Influence of load duration on strain seasitivity for dynamic stress analyses. If the time duration becomes smaller, the stress level must be higher since it takes a combination of stress and time under load to produce failure of the coating. These correction values are approximate. Precise corrections can be calculated by following steps outlined in SESA papers.

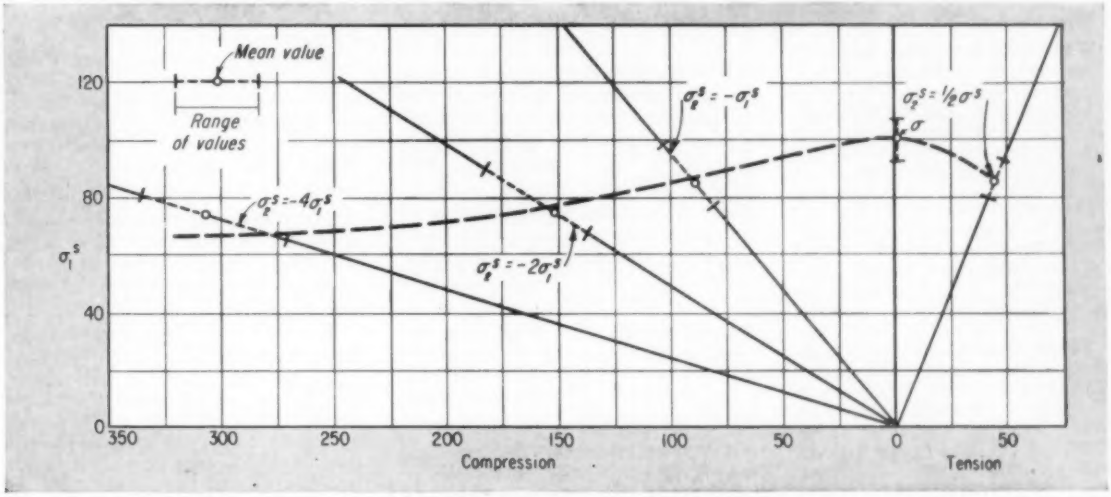

Fig. 7—Failure of brittle coating under biaxial stress conditions. Secondary principal stress reduces the primary principal stress making the equation conservative in design. Strain gages can be used to make a partial correction.

of a series of tests where the biaxiality of the stress field was varied over a wide range is shown in Fig. 7. σ_2 reduces the value of σ_1 required to crack the coating.

The equation, therefore, leads to a value of σ_1 which is conservative in design. A partial correction can be made by calibrating the coating on the component in its actual stress field by using a pair of strain gages mounted on the isoentatic and orientated perpendicular and parallel to the isostatics of the part.

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Some Properties of Stresscoat Under Dynamic Loading, by A. J. Durelli and J. W. Dally. Published in the *Proceedings of the Society of Experimental Stress Analysis*, Vol. XV, No. 1, pages 43-56, 1957.

Further Studies of Properties of Stresscoat Under Dynamic Loading, by J. W. Dally, A. J. Durelli and V. J. Parks. Published in the *Proceedings of the Society of Experimental Stress Analysis*, Vol. XV, No. 2, pages 57-66, 1958.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(F-1) Precision Nylon Balls—Bulletin, 2 pp. Precision balls in many sizes, chemical resistant, used as valve components, anti-friction and roller bearings, and many other industrial applications. Ace Plastic Co, 91-30 Van Wyck Expressway, Jamaica, NY.

(F-2) Corrosion Proof Bellows—Bulletin, 4 pp. Pressure temperature rating chart and tabulation of super flexible bellows, flexible couplings and expansion joints with assembly instructions and their applications with various chemicals. Resistoflex Corp, Roseland, NJ.

(F-3) Aircraft Ballbearings—Catalog, 16 pp. Contains sizes, load rating and dimension tables on jet engine turbine mainshaft and accessory ballbearings; also, engineering data on ball bearing design, limiting speeds, lubrication, mounting, separators, and others etc. New Departure Div, General Motors Corp, 269 N Main St, Bristol, Conn.

(F-4) Washers and Stampings—Catalog, 19 pp. Lists complete specifications for standard types of washers. Identifies stock items and lists tools available. Illustrates special shapes available. Contains reference charts. Wrought Washer Mfg Co, 2213 S Bay St, Milwaukee 7, Wis.

(F-5) Machinery Mounts—Bulletin, 6 pp. Information and data on simplified machine installation and vibration control through use of pads and level-rite mounts. Unisorb Div, The Felters Co, 210 South St, Boston, Mass.

(F-6) Special Bearings—Bulletin, 24 pp. Anti-friction ball and roller bearings of unusual shapes and sizes, high temperatures, corrosion resistance and other specialized operating conditions. Industrial Tectonics, Inc, 3686 Jackson Rd, Ann Arbor, Mich.

(F-7) Plugs—Brochure, 11 pp. Pipe fittings and pipe plugs, dryseal threaded NPTF to precision standards. Includes engineering standards and pipe plug specifications. Pipe Plugs, Inc, 1000 N Main St, Wellington, Ohio.

(F-8) Vibration and Shock Mounting Systems—Catalog, 4 pp. Describes variable damped aeronautical and electronic mounting systems. Discusses design and selection of component parts and vibration isolation mounts for instruments. Effective isolation of aircraft vibration by resiliently mounting or suspending equipment. Federal Shock Mount Corp, Div of the Corfund Co, Inc, 1060 Washington Ave, NY 56, NY.

(F-9) Push-pull Flexible Controls—Catalog, 15 pp. Provide positive remote action over long or short distances for continuous or intermittent transmission of reciprocal motion. Describes construction, operating capabilities, maintenance, control dimensions, accuracy and selection procedures. Automotive & Aircraft Div, American Chain & Cable Co, 601 Stephenson Bldg, Detroit 2, Mich.

(F-10) Bronze Sleeve Bearings—Catalog, 12 pp. Describes graphited and plain bronze bushings, cast and machined to blueprint specifications; list of standard stock bushings by size, cored and solid bronze bars. Illustrates controlled lubrication principle, styles of graphiting and standard bushing tolerances. Randall Graphite Bearings, Inc, Greenlawn & Lake Sts, Lima, Ohio.

(F-11) Metal Bellows—Brochure, 4 pp. Describes service for solving complex bellows problems by analytical approach and prototype tooling. Metal Bellows Corp, 27 Mica Lane, Wellesley Hills 82, Mass.

(F-12) Lubrication Equipment—Catalog, 36 pp. Illustrates and describes all types of lubrication equipment, from simple hand guns to complete systems. Alemite Div, Stewart-Warner Corp, 1826 Diversey Pkwy, Chicago, Ill.

(F-13) Precision Ballbearings—Catalog, 44 pp. Engineering information concerning proper application to precision instruments. The Fafnir Bearing Co, 37 Booth St, New Britain, Conn.

(F-14) Filters—Bulletin, 6 pp. Describes filtration equipment for every industrial filtration need. U S Hoffman Machinery Corp, Industrial Filtration Div, Thompson Rd, Syracuse, NY.

(F-15) Water-lubricated Bearings—Catalog, 33 pp. Description of water lubricated bearings and illustrations of uses on various types of industrial equipment. Lucian Q Moffitt Inc, 504 Evans Bldg, Akron 8, Ohio.

(F-16) Mechanical Products—Brochure, 16 pp. General product, services and facility description. Illustrations and recommendations for the proper use of seals, packings and rubber products. Material and design data. Chicago-Allis Mfg Corp, 113-125 N Green St, Chicago 7, Ill.

(F-17) Magnetic and Micronic Filter—Catalog, 4 pp. Filter designed for the aircraft, missile and electronic industry. Efficiency 99% at rated flow per pass, using contaminants 0 to 5 microns. Wilkinson Mfg Co, PO Box 127 Florence Station, Omaha, Neb.

(F-18) Liquid Springs—Brochure, 4 pp. Lists various models of liquid springs used in die sets, pressure pads, and all applications where a high spring force is needed in a small area. Also shock absorbers used in OEM. Can be supplied in desired preload. Taylor Devices, Inc, 188 Main St, North Tonawanda, NY.

(F-19) Industrial Filtration—Bulletin, 8 pp. Disposable media filter, vacuum filter, magnetic and disposable media filter, magnetic separator, settling filter, pressure filter. Delpark Div, Indiana Commercial Filters Corp, Lebanon, Ind.

(F-20) Filters—Brochure, 4 pp. Multi element steel filters, 150 psi operating pressures for industrial fluids and gases. Commercial Filters Corp, 2 Main St, Melrose, Mass.

(F-21) Ballbearing Pillow Blocks—Catalog, 8 pp. Contains sizes, dimensions and load ratings of pillow blocks. Engineering data on design, loading, temperature, vibration, contamination and mounting is given. Also, includes interchangeability table, mounting instructions and maintenance data. New Departure Div, General Motors Corp, 269 N Main St, Bristol, Conn.

(F-22) Precision-instrument Ballbearings—Catalog, 36 pp. Contains sizes, load rating and dimension tables of precision instrument and miniature ballbearings. Also contains engineering data on ballbearing design, torque limits, shaft and housing fits, lubrication, speeds, temperatures, and others. New Departure Div, General Motors Corp, 269 N Main St, Bristol, Conn.

(F-23) Lubricating Equipment—Catalog, 50 pp. Describes line ranging from simple oil cups to complete lubricating system. Design details and many typical applications are included. Oil-Rite Corp, 2318 Waldo Blvd, Manitowoc, Wis.

(F-24) Steel Balls—Catalog, 10 pp. Contains sizes and grades of high carbon chrome and stainless steel balls. Engineering data on ball design, hardness, noise test requirements, interchangeability, and special materials is also given. New Departure Div, General Motors Corp, 269 N Main St, Bristol, Conn.

(F-25) Bellows—Catalog, 16 pp. Basic design data on bellows and assemblies, flexible metal and synthetic hose. Flexonics Corp, 1351 S 3rd Ave, Maywood, Ill.

(F-26) Bearings—Catalog, 129 pp. Includes size, capacity and engineering data on full type roller bearings and cam followers. McGill Mfg Co, Inc, 909 N Lafayette St, Valparaiso, Ind.

(F-27) Vibration and Shock Mounting Systems—Brochure, 4 pp. Describes engineered mounting systems used by the military services, major aircraft, missile and electronic equipment manufacturers. Also,

includes nomograph for vibrating systems. Robinson Technical Products, Inc, Teterboro Air Terminal, Teterboro, NJ.

(F-28) Ball Joints—Catalog, 4 pp. Contains tracings of individual items, specifications, test reports on physical strength, and OEM net prices. Superior Ball Joint Corp, 3901 Trier Rd, Ft Wayne, Ind.

(F-29) Gaskets, Washers, and Packings—Catalog, 30 pp. Design and application of leather gaskets, washers, and packings. Standards, description, and engineering data. Excelsior Leather Washer Mfg Co, Inc, 720 Chestnut St, Rockford, Ill.

(F-30) Precision Cams—Catalog, 12 pp. Describes design, manufacture, inspection and applications for two and three dimensional cams. The Parker-Hartford Corp, 650 Franklin Ave, Hartford, Conn.

(F-31) Technical Data on Springs—Brochure, 40 pp. Design and engineering information on the general spring applications, load deflection tables with complete information on the ordering of springs. Accurate Spring Mfg Co, 3811 W Lake St, Chicago, Ill.

(F-32) Worm Gear Jacks—Catalog, 8 pp. Describes line of jacks with capacities of 2 to 100 tons. Engineering drawings and data included. Duff-Norton Co, PO Box 1889, Pittsburgh, Pa.

(F-33) Heavy-duty Ball Joint—Catalog, 8 pp. Describes heavy-duty type SP ball joint: prices, strength advantages, construction features, design of spring steel retaining sleeve, dimensions and interchangeability of replacement parts. Superior Ball Joint Corp, Fort Wayne, Ind.

(F-34) Liquid and Oil Filters—Bulletin, 15 pp. Filters for cleaning liquids, lubricating, fuel and hydraulic oils. Gives details of construction. William W Nugent & Co, Inc, 3440 Cleveland St, Skokie, Ill.

(F-35) Bushings and Mountings—Brochure, 6 pp. Rubber or neoprene mounted bearings, bushings and mountings. Description of assembly methods and general applications. Engineering sheet as a guide in choosing type of design. Bushings, Inc, 4358 Coolidge Hwy, Royal Oak, Mich.

(F-36) Pillow Blocks—Catalog, 2 pp. Neoprene mounted sleeve type bearing. Listing of outstanding features, sizes and dimensions. Bushings, Inc, 4358 Coolidge Hwy, Royal Oak, Mich.

(F-37) Machinery Mountings—Catalog, 4 pp. Describes construction, dimensions, applications and features of machinery mounting with a built in leveling device. Bushings, Inc, 4358 Coolidge Hwy, Royal Oak, Mich.

(F-38) Thin-section Bearings—Catalog, 24 pp. Technical data on precision and ultra-precision thin-section bearings; design principles, typical applications, engineering factors, and bearing specifications. Split Ballbearing, A Div of MPB, Inc, Highway Four, Lebanon, NH.

(F-39) Lubricators—Bulletin, 8 pp. Describes different lubricators; gives engineering and ordering information, photographs of different applications. Bijur Lubricating Corp, 151 W Passaic St, Rochelle Park, NJ.

(F-40) Fine-pitch Gears—Catalog, 100 pp. Includes complete line of gears, 48 through 200 pitch, to AGMA precision classes 1 and 2, available immediately from stock. U S Gear Corp, 81 Bay State Rd, Wakefield, Mass.

(F-41) Roller Bearings—Catalog, 67 pp. Contains dimensions, load ratings and application data on the complete line of cylindrical bearings. Hyatt Bearing Div, General Motors Corp, Harrison, NJ.

(F-42) Shims and Gaskets—Brochure, 6 pp. Plastic shims and gaskets stock information as to thickness, use, sketches and other data. The Artus Corp, Englewood, NJ.

(F-43) Universal Joints—Catalog, 8 pp. Prices, engineering and purchasing data. The Gray & Prior Machine Co, 614 Windsor St, Hartford 5, Conn.

(F-44) Dry Bearing Material—Bulletin, 12 pp. Description of material, applications and specifications. United States Gasket Co, Plastics Div of the Garlock Packing Co, Camden, NJ.

(F-45) Centralized Lubrication Systems—Bulletin, 8 pp. Lists various benefits and applications of power lubrication. Covers multi-luber and power-drive lubrication systems. Lincoln Engineering Co, 4010 Goodfellow, St Louis, Mo.

(F-46) Universal Joints—Bulletin, 4 pp. Contains basic information on joints and assemblies. Rockwell-Standard Corp, Universal Joint Div, Allegan, Mich.

(F-47) Precision Springs—Brochure, 8 pp. How to specify and order springs; defines terminology used in spring industry; illustrates intricate spring shapes and wire forms; photographs of production, engineering and development facilities. Automatic Spring Coiling Co, 4045 W Thorndale Ave, Chicago 46, Ill.

(F-48) Friction Snubbers—Brochure, 4 pp. Includes cutaway views, performance curves, operating principles, capacities and method of application to railroad cars and military vehicles. Houdaille Industries, Inc, Buffalo Hydraulics Div, 437 E Delavan Ave, Buffalo 11, NY.

(F-49) Duct Insulation and Liner—Brochure, 8 pp. Description and characteristics; acoustical and thermal efficiency; application specifications; thicknesses and facings; ordering and shipping information. Gustin-Bacon Mfg Co, 210 W 10th St, Kansas City, Mo.

(F-50) Packing and Gasket Materials—Catalog, 40 pp. Contains illustrations, descriptions, specification charts and recommendations. Raybestos-Manhattan, Inc, 61 Willett St, Passaic, NJ.

(F-51) Cable Clamps—Brochure, 4 pp. Property table, dimensions, and test results of nylon cable clamps. Weckesser Co, 5701 Northwest Hwy, Chicago, Ill.

(F-52) Ball Screws, Splines and Ways—Catalog, 9 pp. Gives design data on applying antifriction drive elements in mechanism design and typical engineering standards for custom made units. Beaver Precision Products, Inc, 651 N Rochester Rd, Clawson, Mich.

(F-53) Feeders and Conveyors—Catalog, 96 pp. Covers controls, principles of operation, unit specifications and installation methods of electric vibrating equipment, barrel packers, coolers and dryers, magnetic separators and bin level indicators. Photographs, line drawings, installation views and general dimensions of various models. The Jeffrey Mfg. Co, Columbus 16, Ohio.

(F-54) Reinforced Teflon Bearings—Bulletin, 4 pp. Gives data on construction and properties of new reinforced teflon bearings. Dixon Corp, 19-21 Burnside St, Bristol, RI.

(F-55) Precision-instrument Ballbearings—Catalog, 80 pp. Tabular listings of sizes and technical information on instrument ballbearings. New Hampshire Ball Bearings, Inc, Peterborough, NH.

(F-56) Long-stroke Diaphragms—Catalog, 17 pp. Defines seals, gives applications, shows various mounting arrangements, lists stock sizes and materials of constructions. Bellofram Corp, Blanchard Rd, Burlington, Mass.

(F-57) Casters and Wheels—Catalog, 12 pp. Illustrates construction and furnishes specifications on industrial casters in regular, medium-heavy and heavy duty ratings. The Fairbanks Co, 393 Lafayette Street, NY 3, NY.

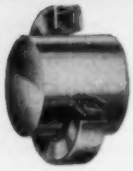
(F-58) Clutches—Catalog, 20 pp. Describes products, including hysteresis and miniature clutches and motor testing dynamometer. Gives specifications, sizes and application information. Magtrol, Inc, 240 Seneca St, Buffalo, NY.

(F-59) Self-lubricating Bearings—Catalog, 20 pp. Complete information, technical data, and specifications about self-lubricating bushings, bearings and washers for industrial equipment, machinery, hydro-electric, high temperature, missile and atomic applications. Merriman Bros, Inc, 195 Amory St, Boston 30, Mass.

(F-60) Flexible Couplings—Catalog, 4 pp. Describes line of flexible couplings: sleeve bearing, rubber cushioned and dihedral gear types. Gives dimensional and capacity information. Ajax Flexible Coupling Co, Inc, 72 Portage Road, Westfield, NY.

(F-61) Shaft Seals—Bulletin, 6 pp. Design, construction and specification information on rotating shaft seals. Illustrated with photographs and sketches. Cartriseal Corporation, 3515 W Touhy Ave., Lincolnwood, Ill.

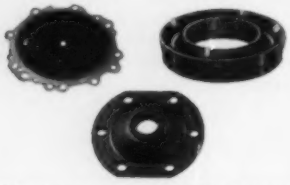
C/R



SHAFT-TYPE OIL SEALS More than 20 types, forming thousands of size combinations for shafts from ¼" to 50" O.D., are available — the majority from stock. These seals are used for the vast majority of shaft sealing problems from simplest dust exclusion to high-speed, high-temperature fluid retention and foreign matter exclusion under rugged operation where high sealing efficiency must be maintained over long service life.

STANDARD END FACE SEALS For sealing problems outside the capabilities of shaft-type seals, C/R End Face Seals are recommended. They require minimum face contact pressure, create minimum friction and give unsurpassed performance under the most severe conditions. Available in two series — long and short — from ¾" to 4" shaft diameter suitable for internal and external pressures to 500 p.s.i., temperatures to 500° F., and peripheral speeds to 15,000 F.P.M. Write for Bulletin EF-100.

OTHER END FACE SEALS C/R continues to make special End Face Seals for heavy-duty applications and severe dirt conditions as in track rollers and final drives in tanks, track-type tractors and similar heavy-duty machinery where shaft speeds are relatively low.



SIRVENE SYNTHETIC RUBBER PRODUCTS The advanced level of compounding and molding elastomers achieved by C/R Sirvene Engineers is widely known. They will design, compound and produce a part to your exact specifications of hardness, elasticity, and resistance to aging, temperature, oils or chemicals — with consistent uniformity and quality. A typical list of products includes oil seal packings, diaphragms, cups, boots, gaskets — to name but a few.

C/R INDUSTRIAL O-RINGS A full range of C/R O-Rings in standard industrial sizes and compounds is now available from stock. Sizes are keyed to the new uniform dash numbering system, SAE Recommended Practice 568 as well as the 6227, 6230 and 6290 series sizes. Write for Bulletin OR-57.

SIRVIS-CONPOR MECHANICAL LEATHER PRODUCTS The range of mechanical leather products includes oil seal packings, cups, boots — any part wherein high tensile strength, flexibility, high resistance to pressure, wear, shock and vibration are desired.

C/R's Conpor impregnated Sirvis leather cups are operating at pressures up to 10,000 p.s.i. They are insoluble in most hydraulic oils, and compatible with a wide range of oils, solvents and gases. C/R Boots of Sirvis leather, canvas, nylon or elastomer impregnated fabric can be produced in sizes two stories high or no bigger than your thumb. Whatever your sealing or protection problem, bring it to Chicago Rawhide.

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Whatever your design problem there is a

Faultless Caster

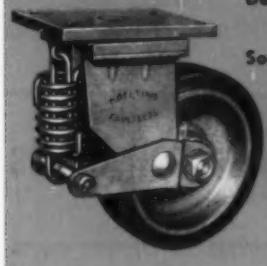
to solve it!

Design Problem:
Shimmyless, Quiet-running Caster for Hospital Carts and Stretchers

Solution:
Series 2400 Medium Duty Swivel Stem Truck Caster. Hardened ball bearings running in 2 raceways machined to closely held tolerances. Precision adjustment of swivel assembly elimates troublesome wobbling of ordinary kind. 5", 8" or 10" dia. wheels for smooth, noiseless rolling.

Design Problem:
V-Grooved Wheel to Follow Angle Iron Tracks

Solution:
Light, medium and heavy duty casters are available with 4" to 10" V-Grooved Wheels to carry loads from 325 lbs. to 15,000 lbs. along unobstructed tracks. Save floor surfaces, eliminate noise and vibration. V-Grooved Wheels have flat outer treads for use on floors.



Design Problem:
Cushion Action Caster for Level Ride over Irregular Floors

Solution:
Series SH300 Spring Action Swivel Plate Truck Caster eliminates bounce. Caster maintains continual floor contact. Durable, long-lasting spring and draw bars, on center line of wheel, absorb shock and lengthen life of ball bearings, raceways and wheels.

Design Problem:
Scaffold and Platform Caster that Double Locks against Movement

Solution:
Series C900 Scaffold Caster has Brake that simultaneously locks both swivel and wheel. Scaffold will not creep. Foot or hand operated brake lever locks in up position . . . releases in down position. Large diameter wheel for smooth rolling over ordinary obstacles.

Design Problem:
Sealed Caster Bearings for Use in Extreme Temperatures or Moisture-laden Air

Solution:
Series 900 GS Swivel Plate Truck Caster has built-in protective grease seals around main load, thrust and wheel bearings. Exclude water, chemicals, dirt. Prevent grease leaking to floor, assure easy maintenance, low upkeep.

Design Problem:
Exciting, All-New Caster Concept To Enhance Your New Furniture Line

Solution:
Royal-Roll, the "King of Casters" combines unique styling and time-tested furniture caster engineering. Double ball bearing swivel, non-marking wheel and hooded horn. Spherical black wheel with bright nickel or brass horn. Stems for wood, tubular metal and cast legs.

For FREE Condensed Catalog, or more information on specific Casters, fill out coupon today. Or contact your nearby Faultless Distributor who is listed in classified directory under Faultless heading.

Tell me more about:

- ☐ Series 2400
- ☐ V-Grooved Wheel
- ☐ Series SH300
- ☐ Series C900
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Faultless Caster Corporation
Evansville 7, Indiana

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Title _____

Company _____

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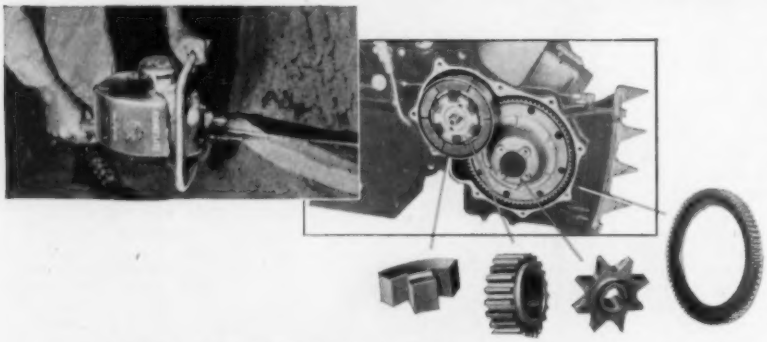
Mass produced to close tolerances in automatic presses, Oilite* Powder Metal Parts and Bearings allow savings up to 55% and higher, slash tooling time and reduce tool costs. A wide choice of ferrous and non-ferrous metals and alloys are available to meet service requirements.

SAVE OVER ONE MILLION DOLLARS A YEAR BY USING OILITE PRECISION PARTS!

THIS KIT contains Oilite Parts produced for a score of companies who save over $1 million annually by specifying Oilite! Savings like this are typical with Amplex customers who manufacture appliances, power tools, machinery, engines, motor vehicles and many other products.

POWER SAW MORE ECONOMICAL WITH OILITE GEARS AND SPROCKETS



The manufacture of this popular power saw makes certain of dependable service by using extra tough, longer-lasting steel Oilite gears and sprockets. The Oilite powder metal parts save this customer over 50% of what he formerly paid to have the same parts machined from steel.

Contact your local Oilite Engineer for complete design and purchasing information. He'll gladly survey your component needs for possible savings at no obligation to you. Look for him in the Yellow Pages of your telephone directory under "Bearings—OILITE" or write to Dept. B-9

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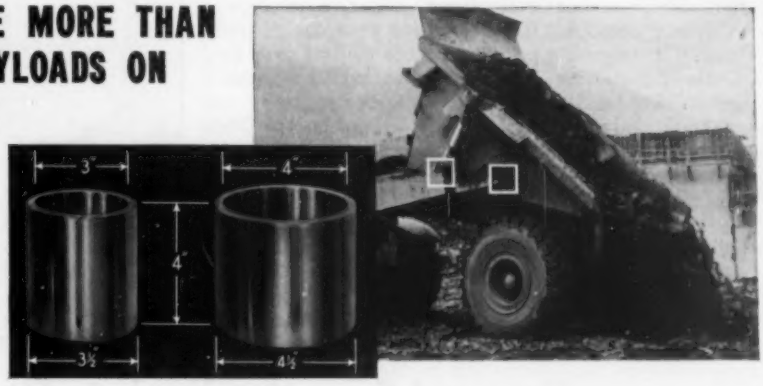
SELF-LUBRICATING BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

A CHRYSLER OILITE® PRODUCT

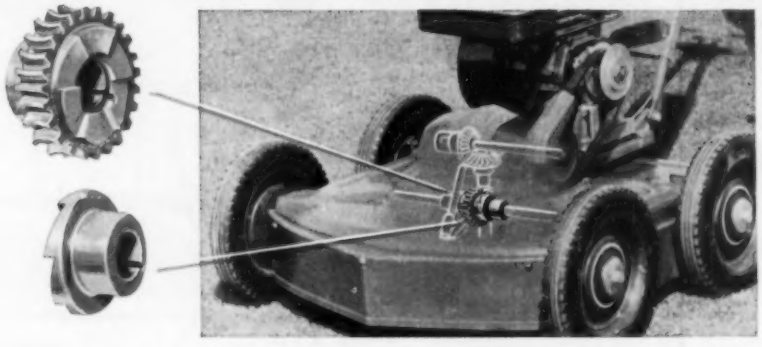
OILITE POWDER METALLURGY

OILITE BEARINGS PROVE MORE THAN MATCH FOR 34-TON PAYLOADS ON ATHEY DUMP TRAILERS

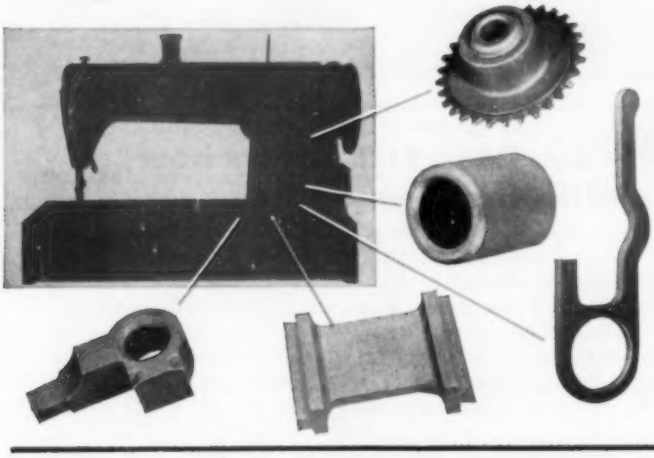
Oil-cushioned against shocks and impacts, these Oilite heavy-duty bearings withstand years of punishment while demanding a very minimum of maintenance. Self-lubricating, they help make Athey trailers more dependable and more maintenance-free. Yet, Oilite Bearings cost far less than many other type bearings.



ACHIEVE MAXIMUM SAVINGS BY COMBINING 3 UNITS INTO 1



The Oilite Bronze component (left) serves simultaneously as differential, oil pump piston cam and over-running clutch. The part engages a 2nd Oilite ratchet fixed to the drive shaft. Combining 3 parts into a single Oilite unit helps make this power mower lighter, more dependable and results in a substantial reduction in cost.



SWITCHING TO OILITE HELPS KEEP THIS MANUFACTURER COMPETITIVE

Faced by price competition and rising costs, one sewing machine manufacturer re-examined all of his component costs. Result: he is now using a number of ferrous-base Oilite gears, eccentrics and sprockets. Mass-produced by automatic presses, these Oilite components cost far less, are quieter and longer-lasting than the parts formerly used.

the most trusted name in powder metallurgy!

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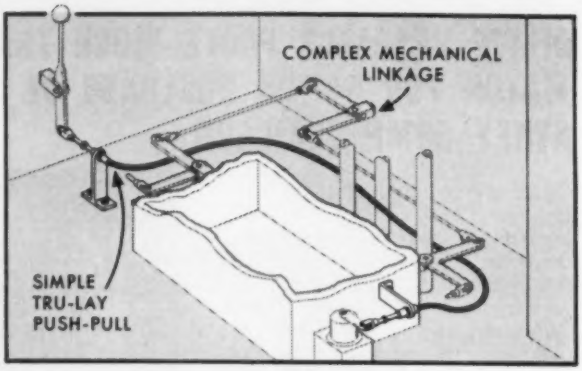
TRU-LAY *PUSH*-PULL CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

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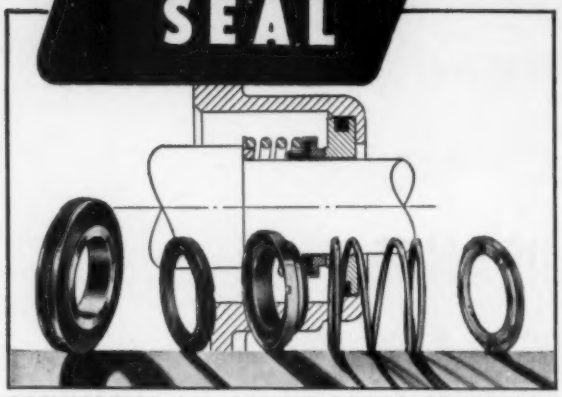
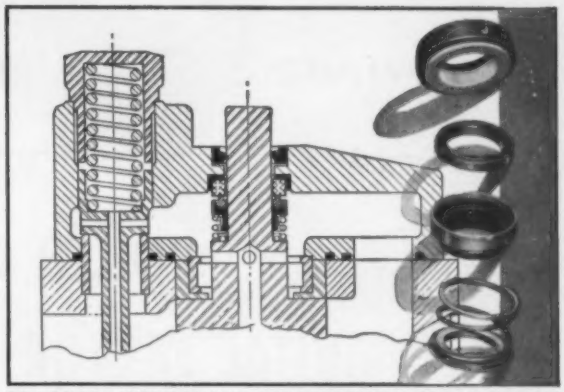
ROTARY SEAL SPECIALIZED SEAL ENGINEERING



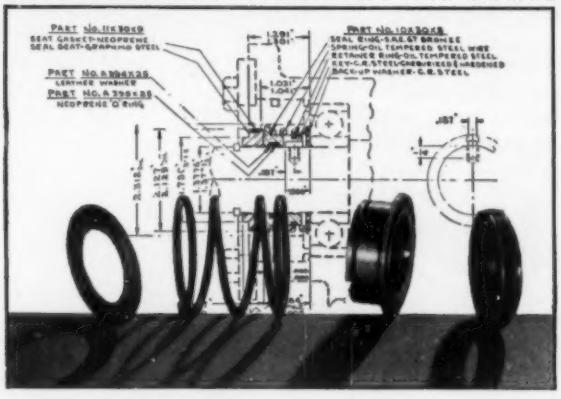
COMMERCIAL AIR CONDITIONING EQUIPMENT

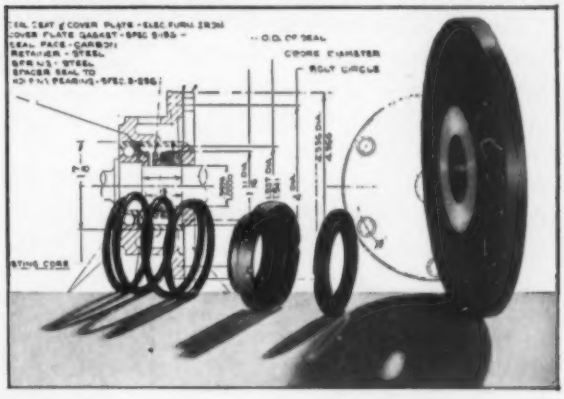
HIGH-PRESSURE HYDRAULIC OIL PUMPS



TRACTOR HYDRAULIC DIRECTIONAL FLOW VALVE

AUTOMOBILE AIR CONDITIONING COMPRESSORS





These ROTARY SEALS are "*tailor-made*" to solve specific problems

No off-the-shelf stop-gaps or compromises here—these Shaft-Sealing problems are tough, and it took specialized development to come up with precisely the *right* Seal to meet all the conditions successfully in each case.

It takes experience plus painstaking and ingenious engineering to produce these right answers, too—the kind of experience that only years of specialization can provide. Since the introduction of the basic ROTARY SEAL principle years ago, we have met and overcome the challenge of hundreds of tough assignments like those illustrated, for leading manufacturers in every field.

If you manufacture HYDRAULIC DEVICES—APPLIANCES—GEAR BOXES—AGRICULTURAL EQUIPMENT—PUMPS—AIR CONDITIONING—or any other line where secure Shaft-Sealing *must* be a certainty, call in the ROTARY SEAL experts, preferably at the drawing board stage. With our expanded sales engineering and production facilities, it's ten to one we can "tailor-make" exactly the right Seal to do *your* job.

Shaft-Sealing with Certainty

ROTARY SEAL DIVISION
MUSKEGON PISTON RING CO., SPARTA, MICHIGAN

BEARING BRIEFINGS

One in a series of technical reports by Bower

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

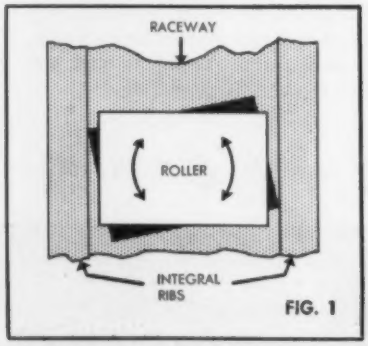
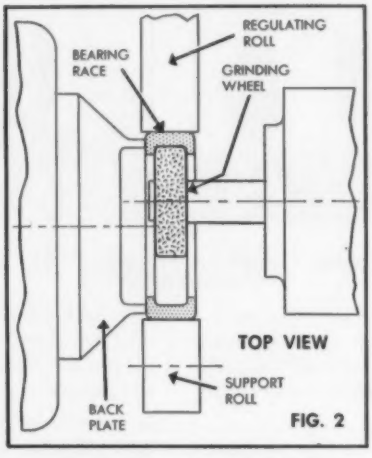
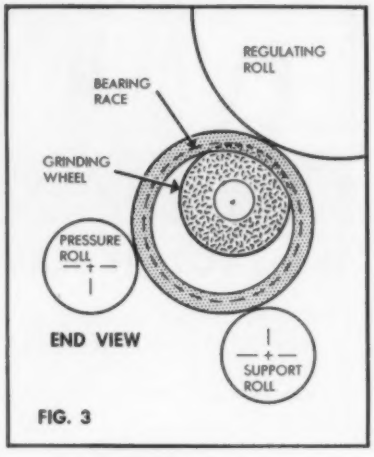


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.

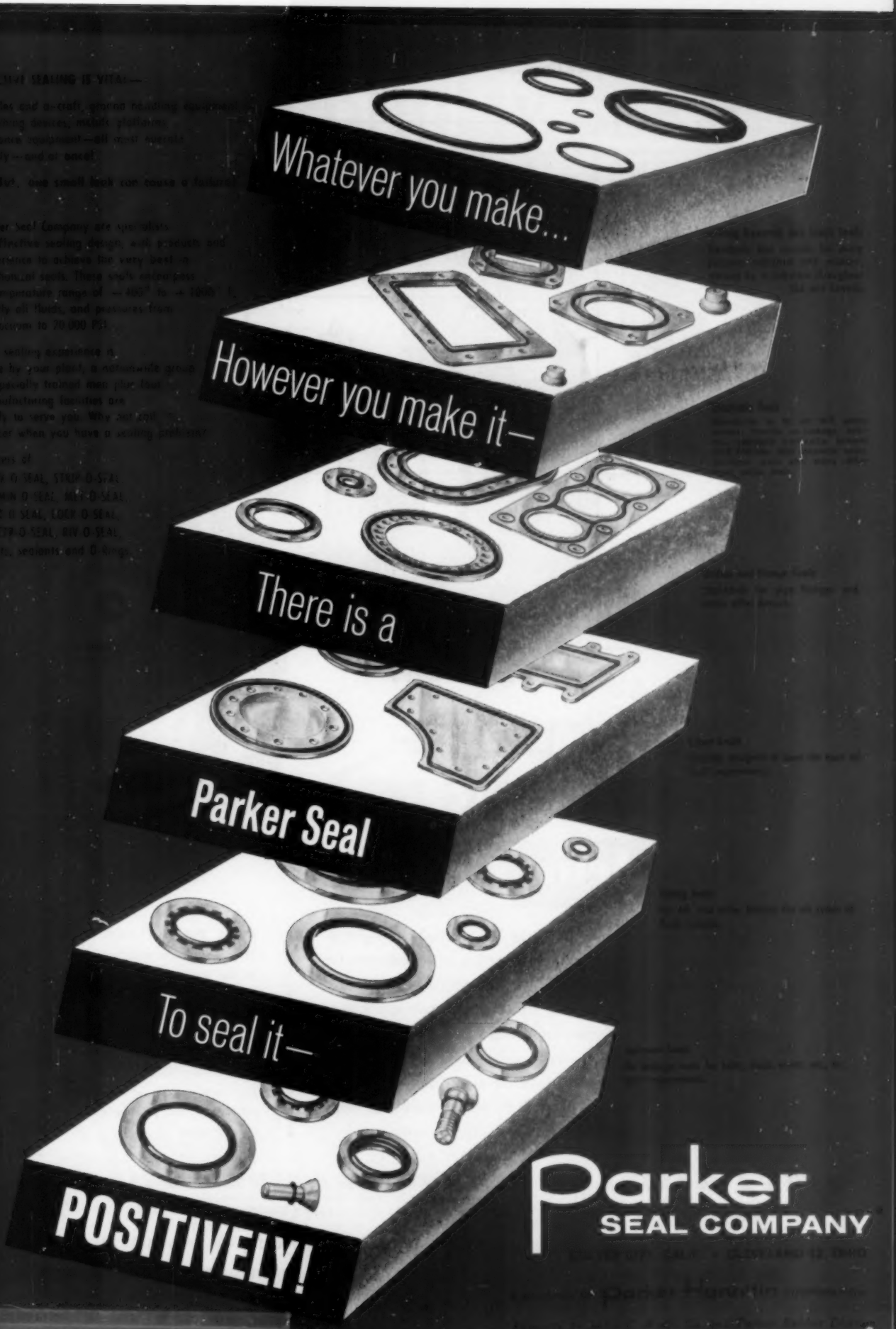


★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN


Whatever you make...
However you make it—
There is a
Parker Seal
To seal it—
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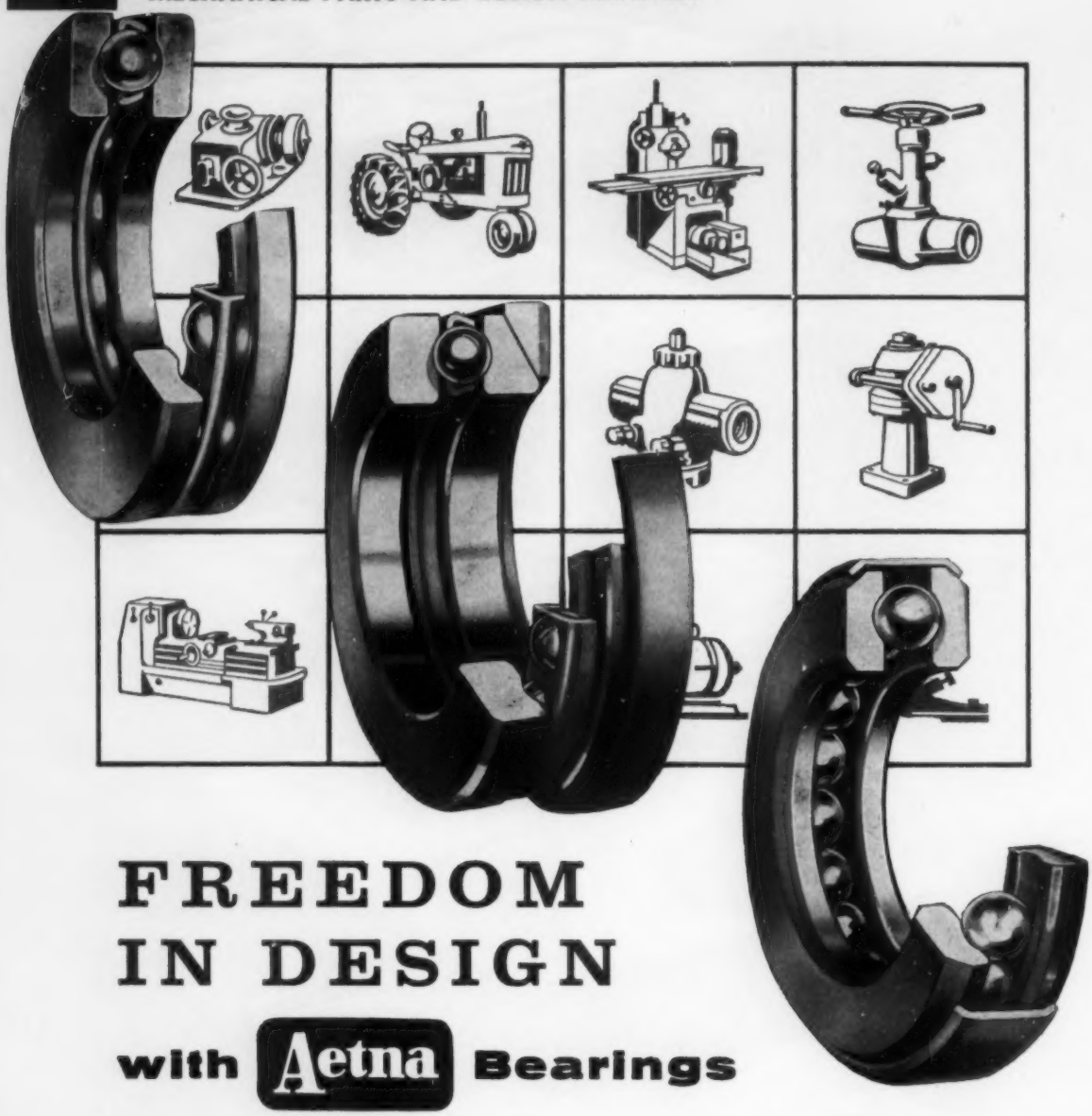

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Designers have learned that they can depend upon Aetna original thinking and creative engineering to provide greater freedom of design in meeting their anti-friction problems.

In the solution of difficult problems, Aetna's specialized knowledge and experience—combined with fresh viewpoints, ingenuity and a sincere desire to serve—have produced practical combinations or arrangements of an unusual nature which enabled designers to produce better operating, more simplified equipment at lower manufacturing costs.

CALL UPON AETNA WHEN you have equipment in the design stage which presents special bearing problems. Our experienced, creative engineering department will gladly work with you to produce the special bearings or precision parts which meet your design requirements.

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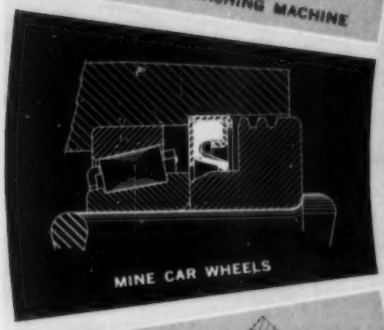
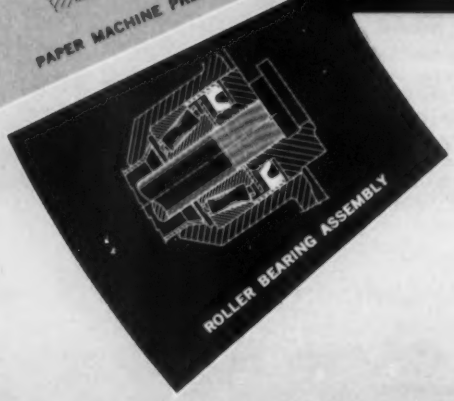
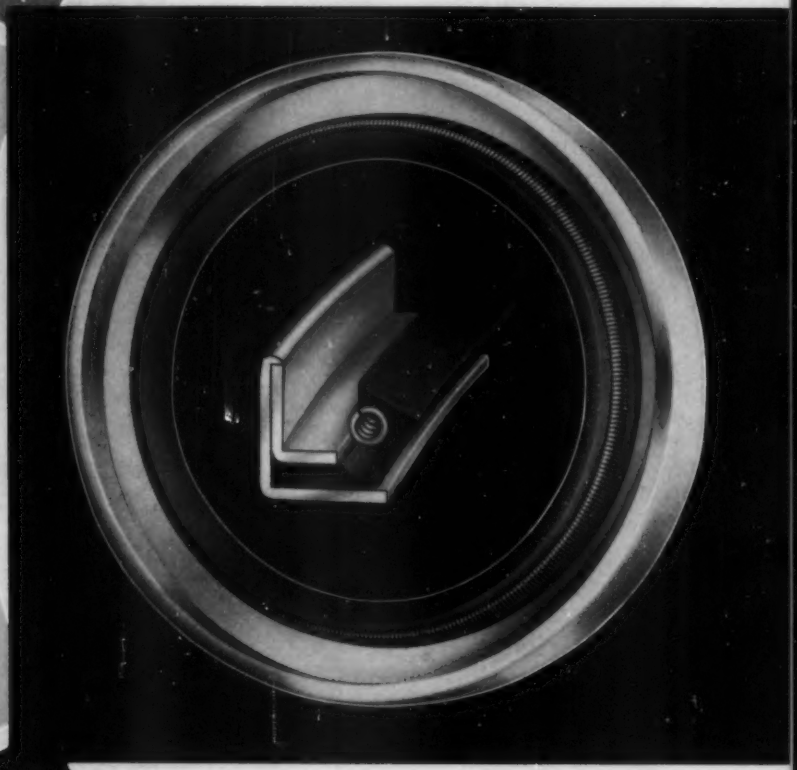
NEED AN OIL SEAL THAT'S



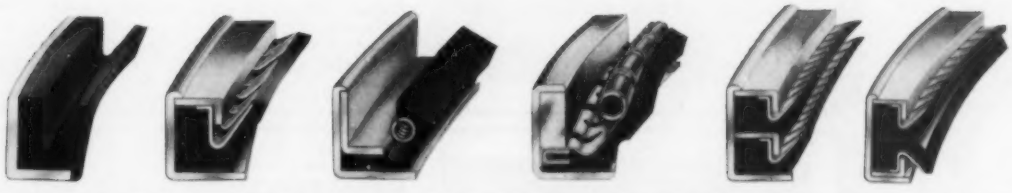




DEPENDABLE, EASY TO WORK WITH?

GARLOCK KLOZURE* Oil Seals do a complete job of protecting bearings—they seal in vital lubrication, seal out harmful dirt and foreign matter. Klozures are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive and free running . . . withstand temperatures from −40°F to +250°F constant, +300°F intermittent. For the more extreme applications, Garlock furnishes sealing elements that resist practically any fluid, and are serviceable as high as +500°F. Garlock Klozures are easy to install, last much longer—this drastically reduces downtime, saves countless maintenance dollars.

You can choose from a wide range of designs. There's a Klozure model to match any service condition. For example:



Model 71—Garlock Bonded Springless Klozure Oil Seal used where heavy lubricants are to be contained and dirt excluded. Especially suited for installation where space is limited.

Model 53—Klozure with finger spring, very efficient for normal and high speed oil sealing on all size shafts from 3" to 41⅜". Model 63 finger spring type seal available for ¼" to 3" shafts.

Model 66—Single lip-type Klozure with garter spring for sealing oil at normal and high speeds.

Model 64—Klozure Oil Seal with combination finger and garter spring for use on large shafts (8" to 48¼") operating under severe conditions.

Dual Types—Klozure Oil Seals are also available in dual tandem (left) or dual opposed constructions for unusual sealing problems caused by operational or environmental conditions. Either finger or garter spring type available.

In addition, where equipment cannot be dismantled easily, Garlock offers split-Klozures which meet the need for a unit-type oil seal where a solid, one-piece design cannot be used.

COMPLETE DESIGN INFORMATION is contained in the new Garlock Klozure Oil Seal Catalog 30. Here, you'll find sections on how to select the proper Klozure, suggested applications for each of the many types, materials of construction, installation, maintenance, and an extensive list of sizes and part numbers.

Your local Garlock representative can furnish you with a copy. Discuss your design problems with him; he can recommend from the famous Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seal for every need. Or, write

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I-S SPRINGS of beryllium copper *can help you*

IMPROVE YOUR PRODUCT'S QUALITY, REDUCE YOUR COST, INCREASE YOUR PRODUCTION

Instrument Specialties Company specializes in the design and custom manufacture of age-hardened alloy springs. With our specially developed processes and machines, our engineers are able to realize the fullest performance potential from the superior spring materials around which I-S service to designers and manufacturers has been developed.

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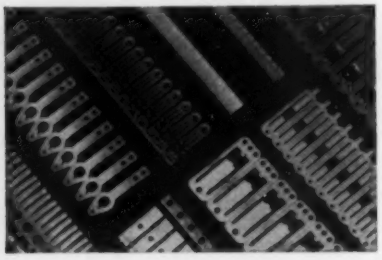
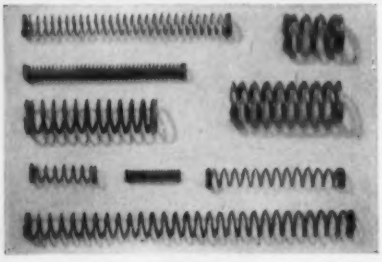




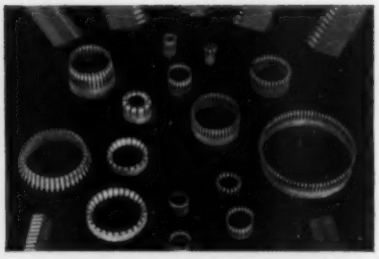
STRIP SPRINGS

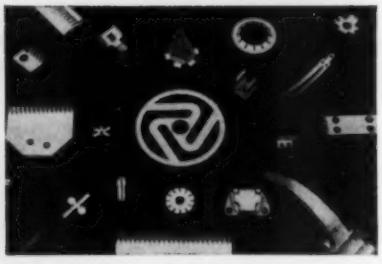
Fabricated from beryllium copper.
Easily handled, readily broken apart by hand or used in automatic or semi-automatic assembling devices and contact riveting machines.
Individual pieces may be broken off without trace of burr.
Eliminate sorting, untangling and handling of loose pieces.
Springs may be produced in strips to various shapes; formed angles may be held within plus or minus one degree.
Heat treated in multiple fixtures to insure uniformity, close tolerances and elimination of variations in spring-back.

COIL SPRINGS

Made from laboratory tested beryllium copper wire. Special coiling and heat treating equipment insures 100% uniformity.
Guaranteed rigid tolerances held on diameter and load tests at specified deflection.
These factors combine to assure increased service life through higher endurance strength – make products perform more consistently by eliminating drift, set or fatigue. Furthermore, they eliminate expensive hand adjustment and reduce inspection costs of finished product.

FOR LOW ACTIVITY





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We are equipped to supply standard mating parts for use with 2C-39, 2C-40, 2C-43 and 3C-37 tubes, or custom made parts in related fields.

Grounding strips and contact fingers can be supplied in standard or special contours.

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For those who need quick delivery of parts in pilot quantities or require a low-cost proving ground for spring designs. I-S methods eliminate expensive tooling. Laboratory controlled, precision produced—yet at lower cost than is possible with permanent, high-activity tools.

We are equipped to handle conventional beryllium copper stampings and screw machine products in short runs or in high production.

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A COMPLETE ENGINEERING AND SAMPLE SERVICE

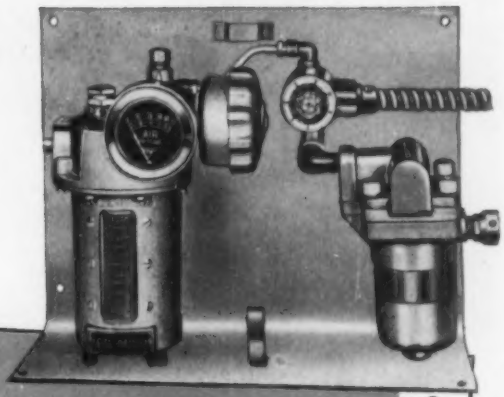
When your product is in the design stage, let us show you how I-S springs of beryllium copper may be designed to fit your needs. Ample stock, flexible facilities, short set-up time speed production of sample lots and trial orders.

How to choose a

LUBRICATION SYSTEM

that provides constant, uniform lubrication

at savings of up to **90%**



use this handy check list:

Will your lubrication system be fully automatic? Oil-Mist starts and stops at the touch of your machine switch.

Will the system that you choose cut oil consumption by 90%? With the Alemite Oil-Mist System you can get better bearing lubrication with only 1/10th as much oil as required by other methods.

Will your lubrication system reduce bearing temperatures? The answer is "yes," if it's an Alemite Oil-Mist System. Reduction in fluid oil friction—plus air flow through bearing—greatly cuts bearing heat.

Will your system extend bearing life? You can definitely count on it, if you choose Oil-Mist. Oil-Mist has extended the service life of many bearings, even under adverse operating conditions, from 10 to 12 times!

Will you have a continuous system? Oil-Mist constantly feeds a uniform volume of fresh oil to each bearing. No oiling schedules. No feast-or-famine lubrication.

Does it protect against contamination? Satisfied Oil-Mist users say yes. A constant flow of clean, air-oil mixture—Oil-Mist—through bearings keeps out dirt and abrasives. Oil-Mist also eliminates wasteful oil handling and applying.

Lubricates any bearing on any machine in One Of Three Ways:

Oil-Mist for high speed anti-friction type of bearings.

Oil Spray for low speed anti-friction and open and enclosed gears and chains.

Condensed Oil for plain bearings, slides, ways, vees, cams, and rollers.

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FIRST in strain measurement

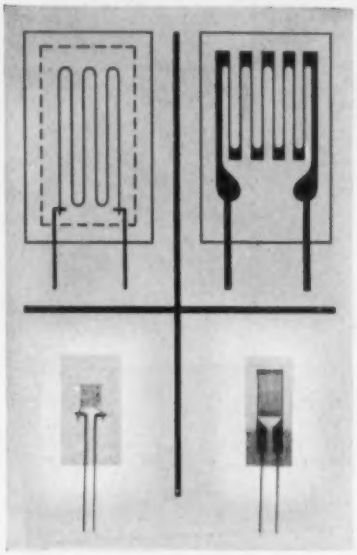
SR-4 BALDWIN BLH LIMA-HAMILTON

STRAIN MEASUREMENT

DATA SHEET No. 1

Useful information about SR-4® strain gages

MEET THE SR-4® BONDED FILAMENT STRAIN GAGE



Bonded wire and bonded foil strain gages are available in a wide range of designs to meet every gaging need. Drawings show typical grid configurations.

Light as a feather, small as a postage stamp, more accurate than a fine micrometer, the bonded filament resistance strain gage has long been accepted by engineers and designers as a virtually indispensable research tool. Its function is to detect the minute strains present at the surface of any solid material, component, or structure under stress, and it is so sensitive that it will react to the pressure of a child's finger on a solid steel column an inch or more in diameter.

Consisting of a looped filament of extremely fine wire or foil, sandwiched between two layers of flexible insulating material, the strain gage is deceptively simple in appearance. Actually, it is the end result of a carefully-controlled, high-precision manufacturing process.

Its operation, as simple in theory as its appearance, depends on the fact that a conductor's electrical resistance changes linearly with longitudinal distortion. The grid of a gage bonded to a surface will stretch or compress slightly with surface strain, thus changing its resistance to a small current passing through it and providing a measure of surface strains as small as one part in a million. Compression of the grid material is possible because of firm bonding to flexible backing layers.

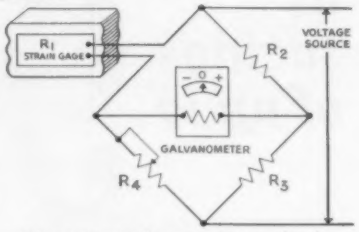
A NEW ERA IN MECHANICAL DESIGN

The SR-4® Bonded Strain Gage was developed in the late 1930s. Designers and engineers soon began to find that this tiny, inexpensive device held the key to some of their most stubborn problems. No longer was it necessary to overdesign critical machine parts and structural members by 400 or 500% to allow for unknown local stresses, to cut-and-try component designs because the exact nature and magnitude of their service loads were not known, or to track down and correct repeated service failures through trial and error methods.

Equally effective in measuring both static and dynamic strains (0 to 50,000 cps and higher), the bonded strain gage quickly found literally thousands of applications in such growing fields as aircraft and automotive design, machine design and construction, and became a familiar tool in virtually every research and development laboratory. It has provided stress analysts with data which made possible lighter, stronger, more efficient turbine blades, connecting rods, gun barrels, locomotives, bridges, dams, artificial limbs, and countless other products of our growing technology. Probably its greatest contribution has been in the aviation field, where it has played an essential role in the development of virtually all modern designs.

THE BASIC STRAIN GAGE CIRCUIT

The change in gage resistance (ΔR) with strain is usually of the order of only a few thousandths of an ohm. To detect and measure these minute changes accurately a modified form of the familiar Wheatstone bridge is usually used. The strain gage, bonded to the surface to be tested, forms one of the resistance arms of the bridge circuit. The bridge is balanced in some manner (e.g., by adjusting R_4) with the gage unstrained. Resistance of the gage changes with the strain. This unbalances the bridge, producing a galvanometer reading proportional to the strain. In practice, static strains are usually measured by rebalancing the bridge while the strain is applied, the calibrated control providing a measure of unit strain in microinches per inch.



Wheatstone bridge provides a simple, highly accurate means of measuring strain gage resistance. Initial balance is achieved by adjusting variable resistor R_4.

Commercial strain indicators, like the transistorized, portable unit shown, include an internal bridge circuit to which the active gage may be connected. When a number of gages are involved in a test, a multichannel switching-and-balancing unit is used to apply the output of each gage in turn to a single indicator and/or recorder.

Transistorized, portable strain indicator permits direct reading of strain in microinches per inch. Operates from self-contained battery or 110 volt, 60 cycle power.

SIGNIFICANCE OF "SR-4®"

"SR-4" is a registered trademark of the Baldwin-Lima-Hamilton Corporation. It is used to identify all of the company's bonded filament strain gages and strain gage instruments.

The S and R are the surname initials of E. E. Simmons and A. C. Ruge, who developed the bonded strain gage independently, but almost simultaneously. The 4 honors the group of four men who initiated commercial manufacture of the strain gage.

Close to a million SR-4® Strain Gages are produced every year. These consist of over 250 different types, for application in virtually every major industry.

There is a right gage for every job. The new B-L-H strain gage catalog contains a wealth of information that could be helpful to you in making the right selection. For a free copy, write Dept 20-I

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Electronics & Instrumentation Division
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SR-4® Strain Gages • Transducers • Testing Machines

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3 NEW BELLOWS DEVELOPMENTS FROM Flexonics

new FLEXONICS Hastelloy* alloy B bellows — to strong chemicals

FLEXONICS new Hastelloy alloy B bellows open new opportunities to the designer for efficient, dependable control of flow and pressure of certain highly corrosive media. For example Hastelloy alloy B is well suited to handle hydrochloric acid at all concentrations and temperatures, including the boiling points, and has good resistance to sulphuric and phosphoric acid, hydrogen chloride gas, as well as many other severely corrosive media. The metal is similar in strength and ductility to alloy steel. FLEXONICS Hastelloy alloy B bellows can be supplied in sizes from 13/32" I.D. to 5-3/4 I.D.

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new miniaturized FLEXONICS bellows... nominal 5/32" I.D.

Seamless, hydraulically formed precision bellows in a wide range of metals and performance characteristics. Exceptional strength . . . and extreme sensitivity to temperature and pressure changes as a result of light wall thickness.

new FLEXONICS miniaturized flexible couplings from stock

As small as 15/32" O.D. in various metals. Transmit rotary motion with absolute zero backlash . . . minimize bearing wear and friction. Direction of rotation may be reversed without loss of action. Accommodate shaft sizes 1/8" to 5/16" diameter.

For design applications that involve the measurement of pressure or temperature . . . a flexible sealer . . . or even low-torque power transmission — a Flexonics Bellows can be your answer. Send an outline of your bellows applications — the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.

B-508

Flexonics BELLOWS

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Hoover announces 3L00 extra light bearings

Now, America's quality bearings come in compact proportions designed to save space! Hoover's new 3L00 series extra light ball bearings provide the solution to bearing problems calling for maximum bore size and minimum housing area. They have outer diameter and width dimensions that are substantially smaller than those of standard light, medium or heavy series bearings of equal bore size.

Hoover 3L00 extra light ball bearings are available in a wide range of popular sizes in open, shielded and sealed types, including lubricated-for-life bearings with Hoover-developed contact seals of TEFLON. For complete information, return the coupon below.

Hoover quality is outstanding!

Micro-Velvet balls are made of selected high-carbon chrome alloy steel, uniformly hardened, and finished so perfectly that roundness and diameter are accurate within millionths of an inch.

Hoover Honed raceways, on both inner and outer rings, are super-smooth, superbly finished. Precision matching of ball complements and raceways assures hushed quietness, long life, superior Hoover performance.

Micro-Velvet and *Hoover Honed* are Hoover trademarks. TEFLON is a DuPont trademark for its fluorocarbon resins.

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PDD-59

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Please send new Bulletin 108, which describes Hoover 3L00 extra light bearings.

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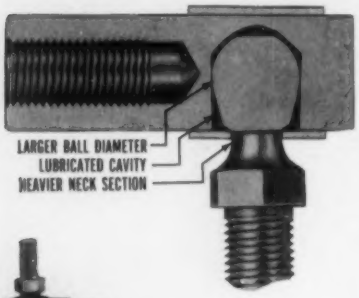

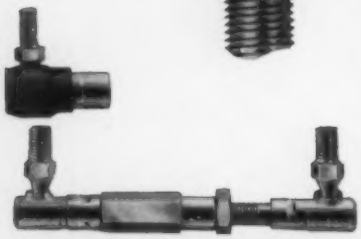

AND YOU CUT COSTS BY 30% AND MORE!

Superior's new simplified ball joint design eliminates unnecessary parts, increases strength, doubles and even quadruples the performance life normally expected from conventional ball joint products.

Initial cost is at least 30% less than old style desgins; and end cost factors are even lower due to Superior's greatly extended component life.

Now used in hundreds of automotive, truck, marine, agricultural and other equipment applications, Superior offers for immediate delivery a complete line of ball joints in thread sizes from #10-32 through ¾-16. All are interchangeable with SAE and other published standards.

Complete ball joint assemblies and "packages" can be designed and supplied for special uses.

SEND FOR FREE TEST LOT 659

SUPERIOR BALL JOINT CORP.

8991 TRIER ROAD • FORT WAYNE, INDIANA

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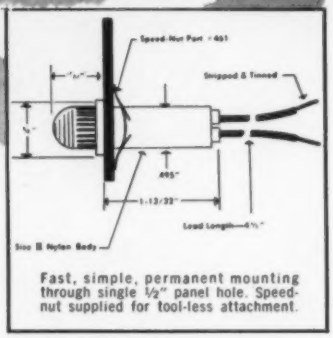
Install it—forget it! Neon glow pilot light assembly outlasts associated equipment—provides life in excess of 25,000 hours under most severe vibration and shock conditions. Completely sealed against ambient dust, or moisture. Extremely low current drain. Available in wide range of models...



Fast, simple, permanent mounting through single ½" panel hole. Speed-nut supplied for tool-less attachment.

WRITE FOR COMPLETE TECHNICAL MANUAL AND OMNI-GLOW CATALOG...

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Edgewater, New Jersey

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catalogs and bulletins.....continued

(F-62) Mechanical Tubing—Brochure, 4 pp. Sizes, weights, uses, and ordering information for hot and cold rolled mechanical tubing, predipped and hotdipped galvanized. Wheatland Tube Co, 1300 Bankers Securities Bldg, Juniper and Walnut Sts, Philadelphia 7, Pa.

(F-63) Porous Ceramic Filters—Catalog, 12 pp. Gives physical and chemical properties, grades, applications, installation, and maintenance data. Filtros, Inc, 601 Commercial St, East Rochester, NY.

(F-64) Linear Actuator—Brochure, 12 pp. Device for the conversion of rotary motion to linear motion and vice versa. Describes basic types of operation, drives, design, assembly and applications. The Anderson Co, 1075 Grant Street, Gary 40, Ind.

(F-65) Compressor Rings and Rod Packing—Bulletin, 4 pp. Gives material properties, specifications, types, services, installation and ordering data. John L. Dore Co, 5406 Schuler St, Houston, Texas.

(F-66) Torque Actuators—Catalog, 20 pp. Engineering information, description, photographs, applications and listings of standard models for the production of reciprocating rotary power. Ex-Cell-O Corp, Greenville Plant, 945 E Sater St, Greenville, Ohio.

(F-67) Rubber Expansion Joints—Catalog, 8 pp. Gives construction, installation, maintenance, engineering dimensions, ordering information and uses. Raybestos-Manhattan, Inc, Manhattan Rubber Div, Passaic, NJ.

(F-68) Bushings—Catalog, 12 pp. Listing, drawings, ordering information and conversion charts for standard ASA bushings. Ex-Cell-O Corp, 1200 Oakman Blvd, Detroit 32, Mich.

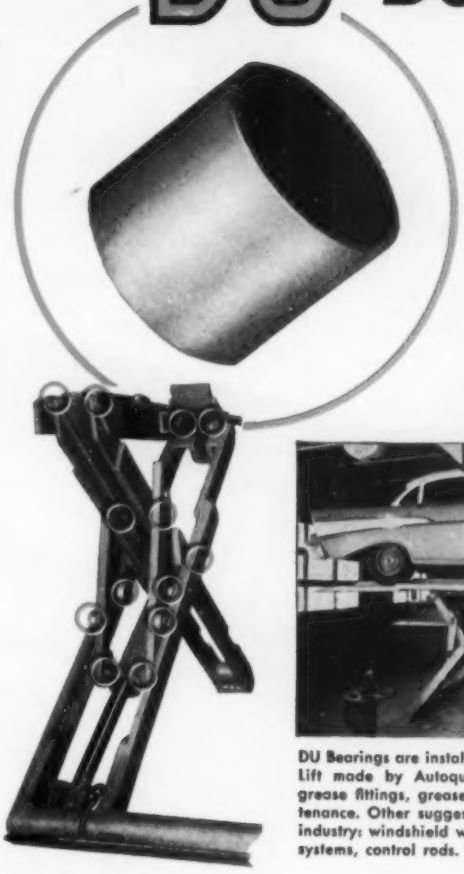
(F-69) Mounting Systems—Bulletin, 12 pp. Contains information on abilities and facilities in design and manufacture of mounting systems. Also information regarding standard, special, and high performance mounting systems. Lord Mfg Co, 1635 W 12th Street, Erie, Pa.

(F-70) Flexible Struts and Vibration Snubbers—Catalog, 8 pp. Struts consist of flexible ball type joints located at each end, suitable for static or dynamic loads. Performance data, specifications and application drawings of struts and hydraulic vibration snubbers. Barco Mfg Co, 552 N Hough St, Barrington, Ill.

(F-71) Flexible Couplings—Bulletin, 6 pp. Describes standard and specially engineered bonded rubber flexible couplings. Specifications, design and selection data. Lord Mfg Company, 1635 W 12th St, Erie, Pa.

(F-72) Heat Exchanger—Bulletin, 4 pp. Description, price sheet and uses of the plate coil heat exchange surface in the industrial heating and cooling processes. Dean Thermo-Panel Coil Div, Dean Products, Inc, 616 Franklin Ave, Brooklyn 38, NY.

New Glacier DU Bearings



". . . less than 1/6th the coefficient of friction we had previously achieved at 15,000 psi."

J. E. CLARKE, President
Autoquip Corporation

DU Bearings are installed at vital bearing locations on the Lift made by Autoquip Corp. DU eliminates need for grease fittings, grease grooves, grease guns—and maintenance. Other suggested applications of DU in the auto industry: windshield wipers, steering columns, suspension systems, control rods.

In search of a "permanent" or "dry" bearing for their Porta-Contact hydraulic lift, Autoquip engineers tested new Glacier DU bearing material. To their amazement, DU bearings had less than 1/6th the coefficient of friction of the best material previously tested. Under endurance runs, DU gave equal to three years' service without so much as a squeak. Now, after nearly one year of actual lift operation, not a single bearing problem has arisen!

DU is a patented composite material consisting of a steel-porous-bronze interlayer impregnated with a lead-filled TFE* fluorocarbon resin. It has greatest structural strength, heat conductivity, and thermal stability of any dry bearing . . . withstands temperatures from −328° F to +536° F.

Exhaustive testing of DU has permitted the establishment of curves relating bearing life to various load-speed combinations. Designers can quickly predict DU bearing life by referring to these curves—and other design data—found in Bulletin DU-458. Ask your bearing manufacturer about it, or write to SPECIAL PRODUCTS DEPT., United States Gasket Co., Camden 1, N. J.

United States Gasket

*Teflon, DuPont Trademark
Fluon, I.C.I. Trademark*

Plastics Division of GARLOCK

WRITE 327 ON READER SERVICE CARD 327

Now SKF has improved the spherical roller bearing it invented!

This new spherical roller bearing offers even higher capacity than SKF's original, self-aligning bearing – and meets the needs of today's faster, more productive machinery. In some cases, the increase in capacity is as much as 54% – corresponding to more than 4 times longer service life!

Here's how these improvements have been obtained:

1. Eliminating undercuts and integral flanges – helps provide space for larger rollers and longer effective contact between rollers and races.

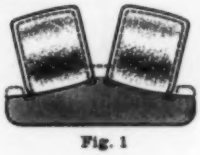


Fig. 1

Fig. 2

2. Using symmetrical rollers, unrestricted by flanges – ensures uniform load distribution over the roller length at all times, even under heavy thrust load.

3. Using an axially floating guide ring – provides effective roller guiding, and minimizes friction at roller ends.

Fig. 3

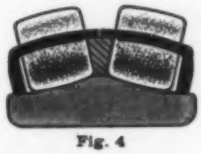


Fig. 4

4. Using a strong "window-type" cage for each row of rollers—helps ensure dependable operation over a full range of loads and speeds.

5. Placing a lubricant duct in the center of the outer ring—helps channel lubricants directly to the rollers and push contaminants away.

Fig. 5

For full details on this new high-capacity spherical roller bearing call the nearest SKF sales office or authorized SKF distributor listed in the yellow pages of the telephone book.

5931

Spherical, Cylindrical, Ball, and Tyson® Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

®REG. U. S. PAT. OFF.

A Sealing Problem?

Get the answer from PRESSTITE

PRODUCT	SUGGESTED APPLICATIONS	CHARACTERISTICS
Permagums ® No. 576 Series	To seal auto bodies and refrigerator seams, for plugging and general sealing, window glass bedding and glazing.	Over 30 varieties of non-oxidizing, non-drying, non-staining, soft sealers. Stable at high temperatures, remain soft and flexible at low temperatures. Colors range from black to white. Extruded beads, tapes, bulk. Hand, knife or pump application.
Elastic Compounds No. 160 Series	To seal double glass in refrigerator display cases, external seams and joints to be painted, aluminum sheeting, automotive flange sealer.	Tough, rubber-like moldable sealers. Non-staining, non-bleeding. Excellent adhesion gains with aging. Extruded in beads, tapes as thin as 1/32", special shapes.
High Temperature Sealers No. 589 Series	To seal seams with joints exposed to high operating temperatures, as hot air ducts, automatic washers.	Withstand temperatures to 450°F., retaining flexibility and adhesion, remaining soft and plastic. Tapes, beads, bulk.
Metal Putties No. 217 Series No. 218	To fill voids in castings, auto body dents and aircraft filleting.	Resin base with aluminum filler. Can be sanded or polished to smooth metallic finish. Thermosetting types with good heat transfer characteristics.
Wat-R-Bar ® No. 586.7	To seal between similar and dissimilar surfaces, as entry of refrigerant tubes and wiring into inner lining, entry of refrigerant lines into outer cabinet, fasteners in doors where low temperatures are encountered.	High resistance to freeze-thaw cycles, to water or water vapor. Won't deteriorate with age, non-oxidizing, odorless, tasteless, non-toxic. Will not flow from —40°F. to 400°F., or become brittle at —40°F. Excellent adhesion, cohesion to all clean surfaces. Non-staining to enamels, porcelains. Unaffected by food acids. White or icy-blue colors in bulk or tapes and beads.
Spotweld Sealers No. 261 Series	To seal spotwelded seams and joints, prevent leakage and corrosion.	Soft, very tacky flexible sealers. Non-staining, non-bleeding. Pump and flow gun application.
Plastisols No. 320 Series	To seal joints or seams wherever panels cannot be welded together. Example, auto drip rails.	Pumpable, heat-curing. Applied as a thick paste before curing. Becomes a tough, cohesive, rubber-like material after curing.
Plastic Sealers No. 579 Series No. 582 Sealer	To seal in bag molding of plastic parts. Other plastic sealers for seam sealing.	Non-corrosive, non-staining, non-bleeding sealers with exceptional adhesion.
Presst-O-Cel ® No. 720	To cover pipes and tubes subjected to temperature or humidity conditions that might cause condensation or sweating—as air conditioning or refrigeration lines.	Expanded Neoprene consisting of millions of tiny nitrogen-filled cells. Perfect water and airtightness; oil, acid, alkali resistance; high insulation factor, light in weight, non-inflammable.
Thermal Mastic No. 440 Series No. 446	To accelerate heat transfer in refrigerators and air conditioners.	Mastic materials for heat conduction. Knife or gun application.
Mastic Sealers	To seal spotwelded and riveted seams, seal between rubber and glass, metal and plastic.	Non-corrosive, non-drying, non-hydroscopic putty-like sealers. Tapes, beads, bulk. Hand, spray or flow gun application.
Expanding Elastic Compounds No. 157 and 158 Series	To seal irregular gaps, uneven and hard-to-reach places.	Controlled expansion of sealer from 50% to 125% when subjected to paint bake oven heat. Beads, tapes, special shapes.
Insulation Tapes No. 165	As an anti-sweat pipe insulation, as gaskets, cushions for glass or sound deadener.	Spiral or longitudinal self-sealing wrappings with excellent water resistance, adhesion and flexibility.
Thiokol ® LP Base Compounds No. 1175 Series	To seal riveted or welded joints in steel, aluminum, magnesium, as aircraft fuel tanks. Aerodynamic smoothing compound, wood deck caulking.	Tough, resilient sealers with excellent adhesion, oil and solvent resistance, low temperature flexibility.

the Most Complete Line of Sealing and Caulking Compounds

WRITE TODAY for additional information and technical data on any of the above products . . . or tell us your sealing problem and we will be glad to suggest other products from our complete line.

PRESSTITE SEALING COMPOUNDS

PRESSTITE DIVISION
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WRITE 331 ON READER SERVICE CARD→

Any way you Analyze
Cylindrical Bearing Values...

THE LOGICAL CHOICE IS

HYATT *HY-ROLL BEARINGS*

FIVE DECISIVE REASONS

1 QUALITY

HYATT IS THE RECOGNIZED LEADER in cylindrical bearings . . . the pioneer and most respected name in the field for over two thirds of a century.

QUALITY DESIGNED—QUALITY CONTROLLED . . . a rare combination of ultra-modern technology and traditional devotion to craftsmanship, backed by the unrivalled research and production resources of General Motors Corporation.

HYATT HAS THE FACILITIES AND KNOW-HOW to maintain *prototype quality* in *quantity production*.

LOWEST REJECTION RATE of any cylindrical bearing supplier . . . as reported by our customers again and again, almost without exception.

2 PRICE

EXPERIENCED EXECUTIVES know that price is more than first cost. HYATT offers many advantages in quality, assembly practice and uniformity of product that can reduce over-all cost.

BECAUSE OF PRODUCTION VOLUME, in most cases HYATT can provide prices as low, or lower than, other approved vendors. Low first cost coupled with on-time delivery, dependable quality and expert engineering know-how is a difficult combination to beat.

HYATT SALES ENGINEERS can frequently draw upon their experience to make valuable suggestions for cost reduction in bearing applications.

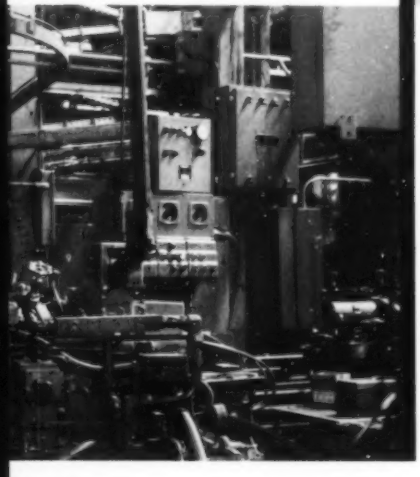
NO BEARINGS CARRY RADIAL LOADS LIKE *CYLINDRICAL*

FOR SPECIFYING HYATT HY-ROLLS

3 DELIVERY

UNSURPASSED PRODUCTION FACILITIES enable HYATT to produce and deliver bearings, in quantity, with maximum speed and economy. Our wide range of product increases the probability that we will have tooling and capacity for even your more unusual requirements.

WHEN SPECIAL BEARINGS ARE NECESSARY, or prototype samples are required, we have the engineering experience, facilities and manufacturing talent to produce them promptly.



4 ENGINEERING

YOU WILL FIND THAT HYATT is usually the preferred source of cylindrical roller bearings with your engineers and designers.

IF YOU ARE NOT regularly specifying HYATT bearings, we believe that closer liaison would acquaint you with the many advantages of designing with HYATT Bearings. Our success with so many customers makes us confident that we can work out a mutually satisfactory program for you.

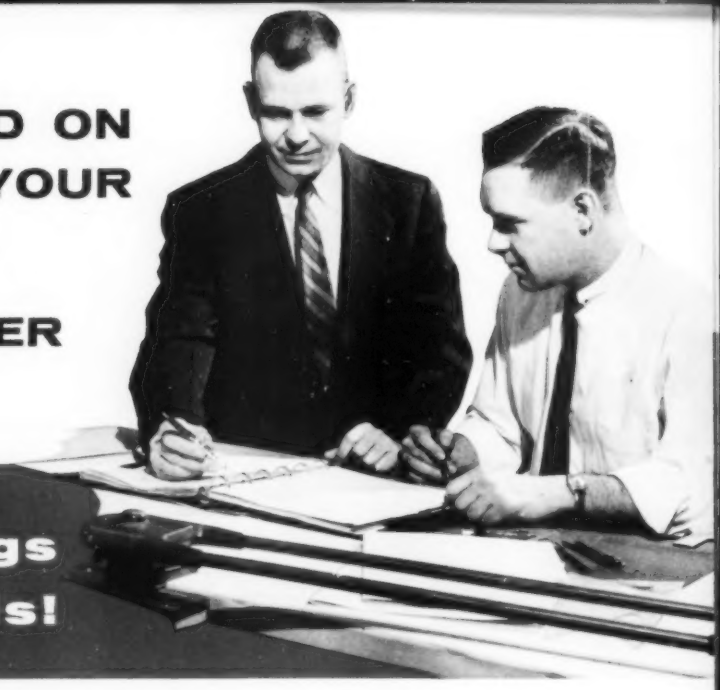
5 SERVICE

HYATT SALES ENGINEERS are trained bearing specialists whose know-how has saved countless man-hours and dollars for customers in almost every kind of industry.

THEIR THOROUGH STUDY of your individual application problems . . . plus conscientious care in every bearing recommendation . . . is a cost-saving "plus value" which is yours for the asking. We urge you to take advantage of it.

BEARINGS . . . AND NOBODY KNOWS THEM LIKE HYATT

YOU CAN DEPEND ON THE ADVICE OF YOUR HYATT SALES ENGINEER



...and the bearings he recommends!

You get the greatest benefit from HYATT engineering service when a HYATT representative is working closely with you on your bearing requirements. This service is available to you at any time. When you have questions that lend themselves to immediate answers, such as price, delivery or specifications of standard bearings, a telephone call can usually provide the necessary information.

just call your nearest **HYATT** *office:*

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427 Middlesex Street
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REMEMBER THESE BUILT-IN HYATT BENEFITS:

- Higher radial load-carrying capacity, size for size
- Minimum space requirements
- Omitted races are optional
- Shaft location without sacrificing capacity
- Easier assembly and disassembly
- Heavier press fits simplify retainment

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

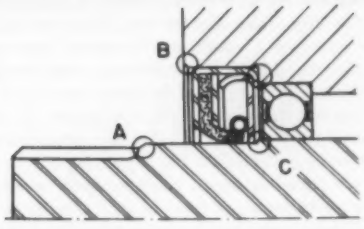
NATIONAL® OIL SEAL LOGBOOK

4 common shaft sealing conditions

. . . and engineering tips that can help you "design-in" better oil seal performance

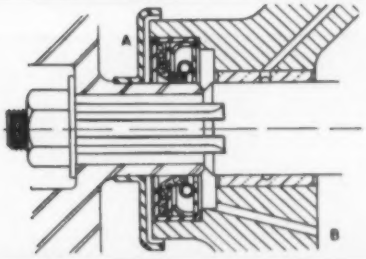
CONVENTIONAL INSTALLATION

Here a standard-design single lip seal retains lubricant and excludes normal dirt, dust and moisture. Sealing lip points in since seal's principal job is retaining oil or grease around bearing. Note that shaft is stepped and chamfered at "A" to prevent damage to sealing lip during installation. At "B", bore is chamfered to facilitate seal entry. At "C", counterboring insures accurate positioning of the seal.



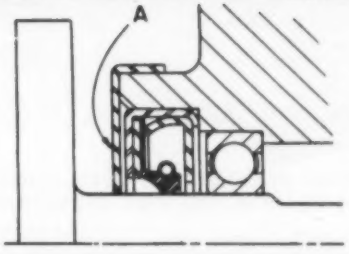
HEAVY DIRT CONDITIONS

Here is a commonly used method of protecting the seal and increasing seal life on applications subjected to extreme dirt conditions. The guard baffle at "A" is welded or swaged to the wheel hub to exclude the major portion of dirt and dust. The drain hole at "B" relieves pressure at the sealing point. In addition to the guard baffle, many manufacturers employ a dual-lip seal to insure bearing protection under extreme dirt conditions.



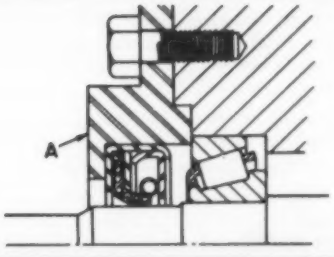
SEALING LONG, HEAVY SHAFT

Many cases of so-called "seal failure" are due solely to poor installation techniques. While today's seals are rugged, they can be rendered non-serviceable if distorted out of round, cocked in the bore, or if the sealing lip is torn. To protect the seal against such physical damage during installation involving a long shaft, a seal protector as shown at "A" may be mounted on the hub O.D.



INSUFFICIENT DEPTH TO MOUNT SEAL

Where the housing does not provide sufficient depth for counterboring, or where seal installation would be difficult or likely to damage the seal, a separate mounting member ("A") can be employed. As before, the shaft should be chamfered to prevent damage to the sealing lip during installation.



NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

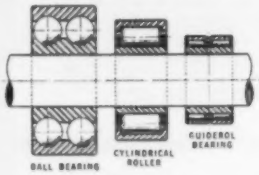
6207

WRITE 335 ON READER SERVICE CARD 335

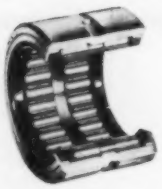
McGILL®

GUIDEROL® bearings offer higher load

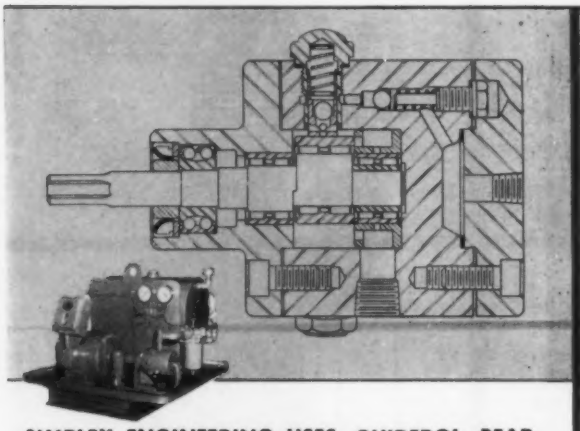
GUIDEROL bearings pack more high capacity performance into smaller radial space. Their construction features the extra capacity of a full complement needle bearing and effective roller control. Center guided rollers limit skewing and prevent binding under adverse conditions in either horizontal or vertical mountings. For a common 1" shaft, the GUIDEROL bearing has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing, the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load. Space-saving GUIDEROL bearings simplify design and cut housing space requirements. Available with or without inner rings in shaft sizes from ⅛" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).



Sealed Guiderol Bearings Protect Performance Life and Cut Maintenance



Pre-lubricated and sealed GUIDEROL bearings lock lubrication in and seal contamination out. Interchangeable dimensionally with GUIDEROL GR Series bearings, they cut maintenance in two ways. Bearings last longer and frequent re-lubrication is not required. 5 different seal combinations are available to fit specific mounting requirements.

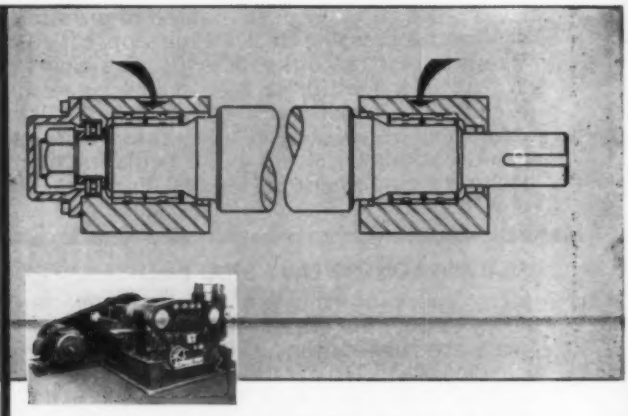


SIMPLEX ENGINEERING USES GUIDEROL BEARINGS IN HIGH PRESSURE HYDRAULIC PUMPS

The SECO "LA" Series pumps, shown in cross section above, are fixed displacement seven piston radial pumps, utilizing unique patented principles which enable them to generate pressures as high as 10,000 PSI without loss of mechanical efficiency. SECO pumps are manufactured by the SIMPLEX ENGINEERING COMPANY, a subsidiary of RACINE HYDRAULICS & MACHINERY, INC.

MCGILL GUIDEROL MT Series bearings are used as shaft support bearings, and center eccentric floating bearings in these and other series Simplex pumps.

SIMPLEX reports unusual success with heavier loads and most satisfactory bearing life through ten years of use of MCGILL bearings. They have helped to produce the strikingly long life for which these pumps have become famous.



KANE AND ROACH LEVELER SHAFTS ROLL ON GUIDEROL BEARINGS

Kane and Roach depends on 26 matched pairs of GUIDEROL bearings to carry the leveling and flat straightening loads resulting from rolling alloy steels of 80,000 PSI yield. They are used on K & R No. 7 Levelers as roll neck bearings on the 11 power driven main leveler shafts and on the pair of adjustable pinch roll shafts that guide entry of alloy steel bars up to 1" thick by 8" wide.

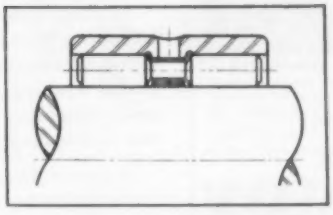
Shown are the matched GUIDEROL bearings in their roll neck mountings. Driven through universal joints at 38 to 114 RPM, the power rollers, supported at each end by pressure lubricated GUIDEROL bearings, provide production speeds of 70 to 210 feet per minute.

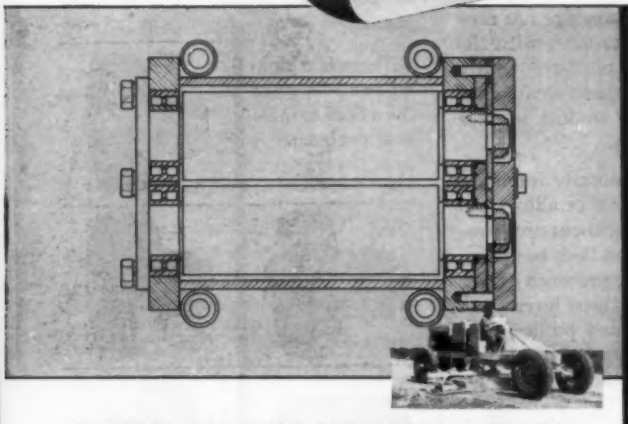
Kane and Roach uses GUIDEROL bearings in many applications with complete assurance of extra capacity and dependable performance with minimum maintenance.

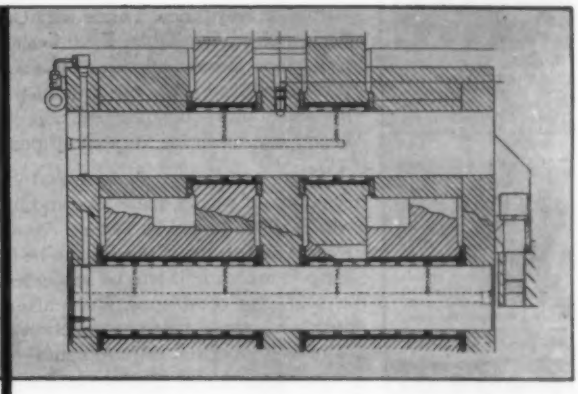
WRITE TODAY FOR FREE McGILL BEARING CATALOG No. 52-A for complete data on McGILL GUIDEROL, CAMROL, MULTIROL and CAGEROL BEARINGS.

capacity in smaller radial space

GUIDEROL BEARING
Cutaway to show center guided roller principle







GUIDEROL BEARINGS WITHSTAND VIBRATION IN LIMA ROADPACKER APPLICATION

GUIDEROL bearings support the off-balance rotors which produce vertical vibration in the six vibrator assemblies of each LIMA ROADPACKER machine. The drawing shows the position of 4 rotor support bearings. A gear motor drives the rotors which are one-half filled with lead to produce vibration for road compacting.

The user states that GUIDEROL bearings were selected because of high capacity in limited diameter and their ability to withstand extensive off-balance vibration. Possible end floating of the separable bearing fits the design very nicely. Performance is considered most satisfactory as the bearings easily resist the eccentric loading.

GIDDINGS & LEWIS SKIN MILLING MACHINE APPLICATION REQUIRES GUIDEROL RIGIDITY — MINIMUM DEFLECTION

GUIDEROL BEARINGS, IN MATCHED SETS are used to mount the reduction gearing in the table drive gear box of each NUMERCOID tape controlled skin milling machine. The drawing shows a partial section of the table drive. GIDDINGS & LEWIS MACHINE TOOL CO. cites excellent performance of the GUIDEROL bearings. Guided rollers in this bearing have eliminated the problem of having the roller bind on the shaft if slight misalignment is present. The drive assembly mechanism reduces back lash by using a pre-loaded gear arrangement and matched bearings. The bearings are flooded with oil through the center of the shaft. Speeds are 1/30 to 460 RPM.

engineered electrical products

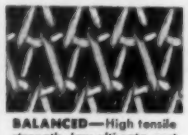
McGILL®

precision needle roller bearings

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING CO., INC., Bearing Div.,
201 N. Lafayette St., Valparaiso, Ind.

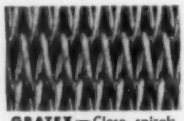
SECTIONAL — Simplest weave, for light loads where low initial cost is desired.



BALANCED — High tensile strength, low ultimate cost belting for operation up to 1300°F. Resists distortion, designed for straight travel.

ROD-REINFORCED — Highest tensile strength and low thermal capacity. It is recommended for high temperatures, up to 2100°F. Undergoes minimum elongation and width contraction.

DUPLEX — Compact structure of great density provides high tensile strength. The close mesh provides smooth surface for carrying small parts and plastic materials.

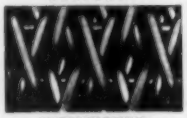


GRATEX — Close spirals retain the advantages of Balanced weave, while adding strength. For cold, medium and some high temperature applications.

DOUBLE BALANCED — A widely used weave combining open mesh of Balanced weave with the strength of Gratex. For cold, medium, some high temperature applications.

MULTI-STRAND

CORDUROY



INTERWOVEN

How to select WOVEN WIRE CONVEYOR BELTS for Continuous Processing

As you know, woven wire conveyor belts are widely used for combining movement with processing in many continuous operations—heat treating metal parts; washing, blanching and freezing food products; annealing and decorating glassware; washing and curing chemicals and plastics.

However, there is no single type of belt construction suitable for all processes. Some require a smooth belt surface, some exceptional strength, others high corrosion resistance. That's why Cambridge has nine basic weaves available. Each is shown here with the important characteristics of the six most frequently used. The last three are special-purpose weaves for installations requiring exceptionally smooth surface and dense mesh for very small parts.

There are several factors that generally influence selection of weave, mesh size and metal or alloy from which the belt will be woven. Among them are: size, weight and shape of product to be handled; temperatures to which belt will be subjected; presence of wet or corrosive conditions. Even after these have been decided, overall belt construction must be designed to meet individual requirements—type of drive, selvage, support and special surface attachments must be selected.

You can see, then, that designing for continuous processing with woven wire conveyor belts is not a simple "nuts and bolts" job. Ramifications build up rapidly to demand the service of a specialist. That's why Cambridge maintains a staff of competent Field Engineers to help you select the Woven Wire Conveyor Belt to make your installation most efficient. You can rely on the experience of these engineers to specify just the right belt for you. In addition, they are thoroughly familiar with basic conveyor design. For the name of your nearest Cambridge Field Engineer, look under "Belting, Mechanical" in your classified telephone book. Or, write direct. Also ask for 130-page Reference Manual of specifications and design information.

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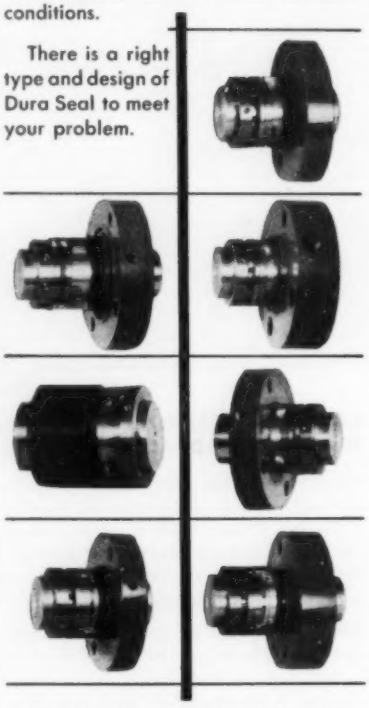

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catalogs and bulletins.....continued

(F-73) Vibrating Feeder—Bulletin, 4 pp. Features, advantages and sales information for a constant volume feeder of materials ranging in density from 40 to 150 lbs per cubic foot. Eriez Mfg Co, 1945 Grove Drive, Erie, Pa.

(F-74) Mountings and Joints—Bulletin, 12 pp. Describes tube form mountings and joints engineered for vibration and shock control. Also contains an application guide, performance characteristics and data, specifications, and installation methods. Lord Mfg Co, 1635 W 12th St, Erie, Pa.

(F-75) Roller Bearings—Catalog, 231 pp. Description of tapered, cylindrical and other types: boundary dimensions, fitting practices, ratings, selection and maintenance data. Bower Roller Bearing Div, Federal-Mogul-Bower Bearings, Inc, 3040 Hart Ave, Detroit 14, Mich.

(F-76) Laminated Phenolic Bearings—Brochure, 6 pp. Describes construction, and basic bearing material. Gives typical applications, physical properties and methods of manufacture. American Brakeblok Div, American Brake Shoe Co, PO Box 21, Birmingham, Mich.

(F-77) Casters—Catalog, 12 pp. Describes constructions, specifications, and applications for line of plate and stem type casters with load carrying capacity of up to 200 lbs. Gleason Casters, 250 N 12th St, Milwaukee, Wisc.

(F-78) Lubricating Equipment—Catalog, 32 pp. Describes line of lubricating items from oil cups to complete systems; materials and specifications. Oil-Rite Corp, 2318 Waldo Blvd, Manitowoc, Wisc.

(F-79) Industrial Casters and Wheels—Catalog, 44 pp. Various types of swivel and rigid casters, as well as wheels in floor protective materials and metal. Capacities ranging up to 15,000 lbs per caster. Albion Industries, Inc, 800 N Clark St, Albion, Mich.

(F-80) Flexible Gear Couplings—Catalog, 19 pp. Describes component parts, specifications, installation and maintenance procedures, and various types of couplings. Includes selection formula, tolerance and service factors. Sier-Bath Gear & Pump Co, 9252 Hudson Blvd, North Bergen, NJ.

(F-81) Miniature Bearings—Catalog, 16 pp. Radial miniature and instrument bearings; miniature roller, pivot and angular contact bearings. Gives tolerances, materials and working diagrams. Landis & Gyr, Inc, 45 W 45th Street, NY 36, NY.

(F-82) Needle Roller Bearings—Catalog, 11 pp. Enginering data on line of bearings used in automatic transmissions, steering gears, and others. Kaydon Engineering Corp, McCraken St, Muskegon, Mich.

(F-83) Casters and Wheels—Catalog, 16 pp. Charts, photographs, sizes and specifications of swivel and rigid models; also accessories and materials. The Hamilton Caster & Mfg Co, 1700 Dixie Hwy, Hamilton, Ohio.

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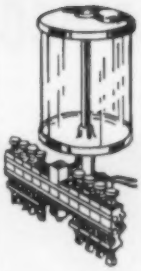
Low cost, dependable lubrication. Drop feeding adjusted by needle valve. Any setting may be locked. Shut-off toggle starts or stops oil flow. Available in many models and capacities from ½ oz. to 1 gal. with ⅛" to ½" pipe thread or for remote mounting.



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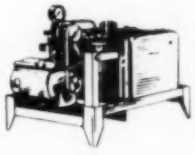

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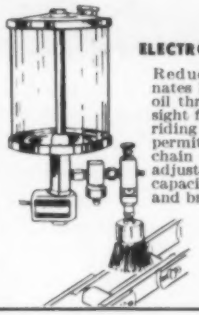

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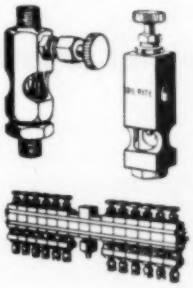
Reduces wear—eliminates hand oiling. Feeds oil through solenoid and sight feed valve to brush riding chain. Solenoid permits oiling only when chain moves. Drop feed adjustable. 9 oz. to 1 gal. capacity. Many styles and brush sizes.



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For any application requiring adjustable visible needle valve control. Friction screw retains hairline adjustments. Large vented sight chambers for observing oil flow. Many styles, single or multiple feed.

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Rugged construction, with glass or plastic sights, revolvable shields and guarded vent hole. Can be taken apart for installation in tight places. Many styles and sizes in both plain and shielded, elbow or straight types.

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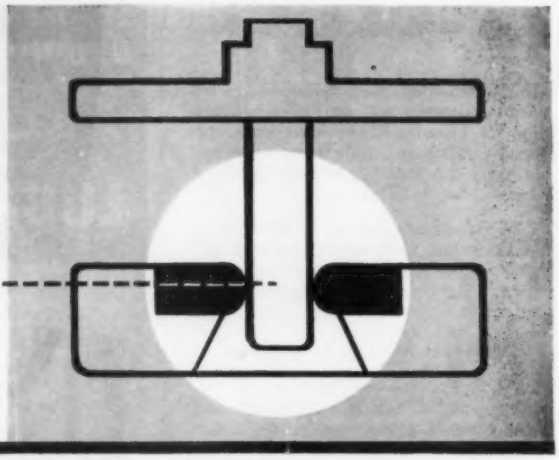

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Specially matched sets of pivots and Bird Jewel Bearings eliminate problems of lubrication, temperature extremes and corrosive actions in gyros and other control devices. Available, either in sapphire or Borosilicate glass, these bearings are manufactured under strict quality control methods to meet the most rigid specifications. Following microscopic examination of all surfaces, the jewels are matched with the precision-cut pivots on comparator screens to assure perfectly matched assemblies. Marked and painstakingly packed, these assemblies reach your plant ready for immediate installation; you can be confident of perfect performance!

Bird Jewels are available in a wide variety of styles in standard sizes or to your specifications.

Special mountings in screws or bushing, adaptable to many mounting arrangements, provide complete assemblies to speed production in your plant. Bird is your responsible source for complete assemblies with built-in accuracy.

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Designed to meet the need for increased protection of jewels in meters and meter assemblies that must withstand severe handling conditions, the Cushion jewel setting provides an economical, new method of assembly.

The Cushion jewel assembly consists of a silicone rubber pad or spring placed beneath the jewel in the assembly operation. The amount of precushioning, or compression under which the jewel is set, will vary with ultimate use. A typical assembly would have the jewel start to compress under a fixed load of 30-40 grams; at 500 grams fixed weight, the jewel is depressed approximately .010″-.015″. Used with a collared pivot, this type of unit performs very well.

In many instances the Cushion type of mounting has enabled customers to use glass Vee jewels in movements that have a moving element heavier than 750 milligrams. Thus, cushion assemblies have helped the inexpensive glass jewel to compete with the costlier sapphire bearings.

Another advantage that several manufacturers have found in cushioned units is reduction in jewel damage during assembly. With conventional mountings, excessive tightening can damage or break the bearing or pivot; the cushioned unit provides a factor of safety in assembly, reducing waste and instrument teardown due to poor judgment in bearing adjustment.

If rejects are putting assembly costs way out of line, why not try samples of Cushion jewel assemblies — yours on request.

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This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 150 standard types and sizes are listed in our Design Manual.*

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(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0469	.1562	.0625
Max.	.3125	.6250	.1960

EXTENDED INNER RINGS . . . available on all above types

FULL BEARINGS

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

Full bearing (Available plain or flanged)

SIZES

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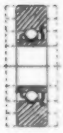
UP and WAFER BEARINGS

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*



A wafer bearing compared with standard equivalent

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.047
Max.	.1875	.4375	.1094

QUALITY PERFORMANCE . . .

is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users . . . at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field . . . to supply you with the finest bearings for your needs at the lowest cost.

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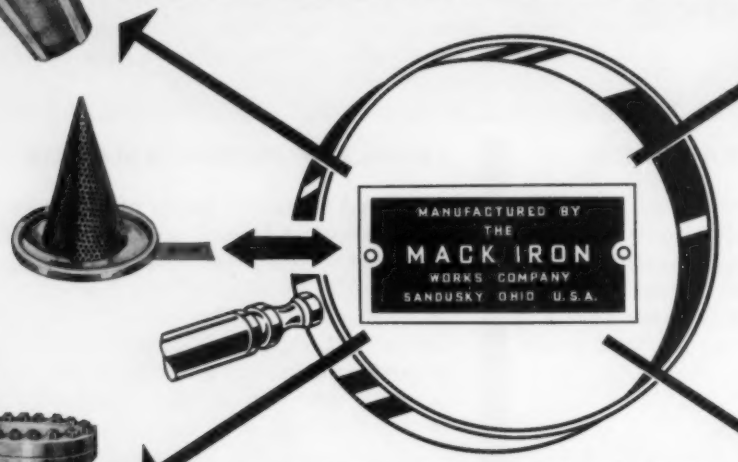

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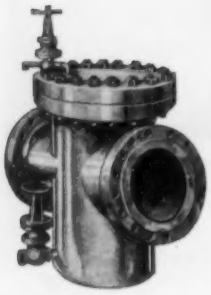

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FOR DRY APPLICATIONS — *Where oil cannot be used!*

1) IN HIGH TEMPERATURES . . . to 750°F. . . . Graphalloy bearings give long service without attention, eliminating shutdowns with their attendant loss of production and cost of replacing parts. They are used where oil or grease would volatilize or where fumes would contaminate the product.

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Cleaning, pickling, plating, scrubbing, galvanizing, dyeing.

Pump bushings and seal rings, step or foot, conveyor, or roll bearings . . . submerged in water, gasoline, acids, dyes, or food products and pharmaceuticals. (Graphalloy is inherently stable . . . no swelling in submersion.)

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Up to 100,000 RPM, where some extremely low viscosity lubricant *other than oil* is used . . . *such as air, water, gasoline or steam.*

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catalogs and bulletins.....continued

(F-84) Self-lubricating Bearings—Catalog, 43 pp. Gives grades, standard sizes, materials, styles and specifications as well as loads and speeds for porous bronze and iron bearings. Keystone Carbon Co, 1935 State St, St Marys, Pa.

(F-85) Industrial Universal Joints—Catalog, 9 pp. Contains photographs of component parts; instructions for assembly and disassembly; efficiency and static torque curves; list of available keyway, spline and square broaches; engineering and purchasing data for alloy steel, and bronze joints. Curtis Universal Joint Co, Inc, Birnie Ave, Springfield 7, Mass.

(F-86) Heat Transfer Equipment—Catalog, 4 pp. Contains construction information, specifications and applications of heat exchangers, coolers and condensers designed for use in chemical industries and oil fields. Young Radiator Co, 709 S Marquette St, Racine, Wisc.

(F-87) Roller Bearings—Catalog, 40 pp. Gives construction, dimensions, load ratings on needle bearings, heavy-duty roller bearings, cam followers, yoke rollers and thrust roller bearings. Orange Roller Bearing Co, Inc, 557 Main St, Orange, NJ.

(F-88) Tubing—Catalog, 4 pp. Describes construction and application; gives technical information, types and accessories. The Zippertubing Co, 752 S San Pedro St, Los Angeles 14, Calif.

(F-89) Cams and Tools—Brochure, 4 pp. Contains description and photographs of cams and tools. Allou Engineering Inc, 15 Elm St, Waltham, Mass.

(F-90) Pillow Blocks—Catalog, 20 pp. Describes graphited and sintered bushing pillow block bearings, bearing cartridges, safety collars and mounting grommets. Contains engineering data; lubrication and installation instructions; detailed drawings of each style and type. Bearing available from ¼ in. through 3-15/16 in. Randall Graphite Bearings Inc, Greenlawn & Lake Sts, Lima, Ohio.

(F-91) Ball and Roller Bearings—Catalog, 24 pp. Gives design and capacity data, life factors, types of seals, charts, sketches and required data form for bearing applications. The Kaydon Engineering Corp, McCracken St, Muskegon, Mich.

(F-92) Tires—Catalog, 46 pp. Describes structure, construction, speed and load ratios of truck, passenger and special duty tires. Also contains table of weights and measures, and maintenance information. Seiberling Rubber Co, Akron 9, Ohio.

(F-93) Heat Exchangers—Bulletin, 6 pp. Describes design and construction; gives dimensions and ordering information. Yates American Machine Co, 729 4th St, Beloit, Wisc.

(F-94) Slide Assemblies—Catalog, 20 pp. Describes standard types and sizes, dimensions, applications, light and heavy duty styles. Russell T. Gilman Co, 624 Beech St, Grafton, Wisc.

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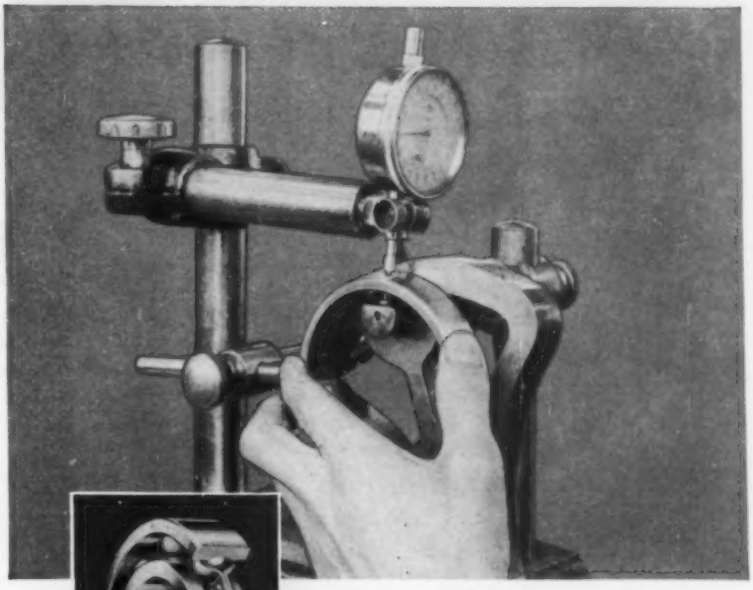

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is just one of the many controls employed in the production of International KOYO Ball Bearings. *Every part of every bearing is inspected — plus 18 separate final inspections!* This *engineered quality* insures you of longer bearing life — the best economy of all.

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Designers may choose from standard, loose or tight internal fit — also ABEC 1-3-5-7 precision.

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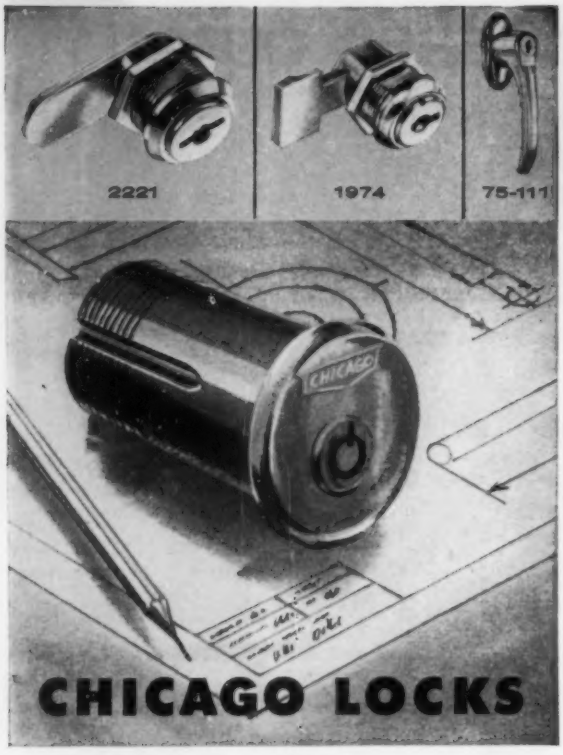

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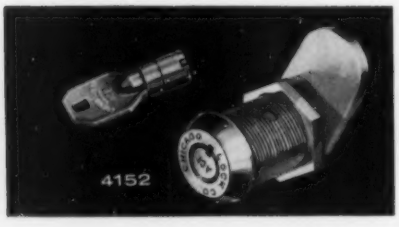

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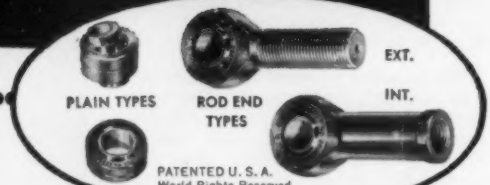

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catalogs and bulletins.....continued

(F-95) Wire Rope Assemblies—Catalog, 24 pp. Wire rope with permanently attached fittings provides an operating control used as part of machinery and equipment or for slings and hoists. Macwhyte Wire Rope Co, 2908 Fourteenth Ave, Kenosha, Wisc.

(F-96) Wire Strainers—Brochure, 32 pp. Illustrates wire cloth and perforated strainer assemblies. Also, stamped metal assemblies, photographs of facilities and products. Wire Cloth Products, Inc, 2801 Congress St, Bellwood, Ill.

(F-97) Ballbearings—Catalog, 8 pp. Gives characteristics, dimensions and availability of standard precision ball bearings from 0.1562 in. to over 3 in. Selection guide shows appropriate types for instruments, aircraft accessories, precision spindles, and others. The Barden Corp, E Franklin St, Danbury, Conn.

(F-98) Universal Joints and Assemblies—Catalog, 28 pp. Description, specifications and performance data for covered and uncovered universal joints, ⅛ in. to 4 in. stock sizes. Application data sheet included. The Apex Machine & Tool Co, 1039 S Patterson Blvd, Dayton 2, Ohio.

(F-99) Roller Bearings—Catalog, 26 pp. Contains bearing dimensions, load capacities, selection data and ordering information. Also provides description of component parts and assembly data. Berliss Bearing Co, 644 W Mt Pleasant Ave, Livingston, NJ.

(F-100) Steel Filters—Brochure, 4 pp. Contains information pertinent to construction, application, sales and engineering of filters for industrial gases and fluids. Commercial Filters Corp, 2 Main St, Melrose 76, Mass.

(F-101) Automobile Axle Shafts—Catalog, 80 pp. Gives specifications for passenger car, truck and bus applications of axle and propeller shafts. The U S Axle Co, Inc, PO Box 111, Pottstown, Pa.

(F-102) Jewel Bearings—Brochure, 4 pp. Type, size and application, individually set to order or mass produced for industrial requirements. Swiss American Jewel Bearings Co, 42 Cherry Lane, Floral Park, NY.

(F-103) Screw Machine Parts—Brochure, 4 pp. Describes custom manufactured precision parts, facilities and tolerances. Photographs and sales information. Sphinx-American Co, 42 Cherry Lane, Floral Park, NY.

(F-104) Industrial Casters—Bulletin, 4 pp. Describes series of truck casters with wheel diameters of 3 in. to 10 in. and load capacities of 75 lbs to 15,000 lbs. Faultless Caster Corp, 1421 N Garvin St, Evansville 7, Ind.

(F-105) Wire Forms—Brochure, 4 pp. Wire parts and small metal stampings made of brass, copper, nickel, tungsten and others are illustrated and given application. Art Wire & Stamping Co, 227 High St, Newark, NJ.

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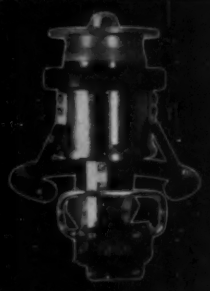

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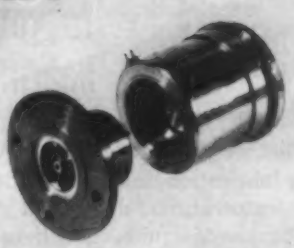

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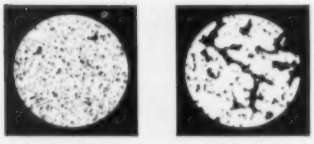

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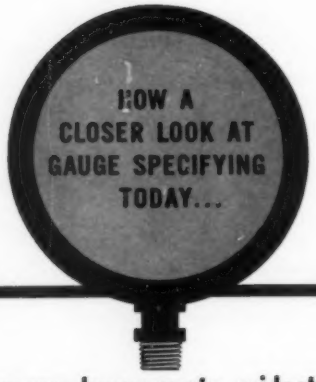

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catalogs and bulletins.....continued

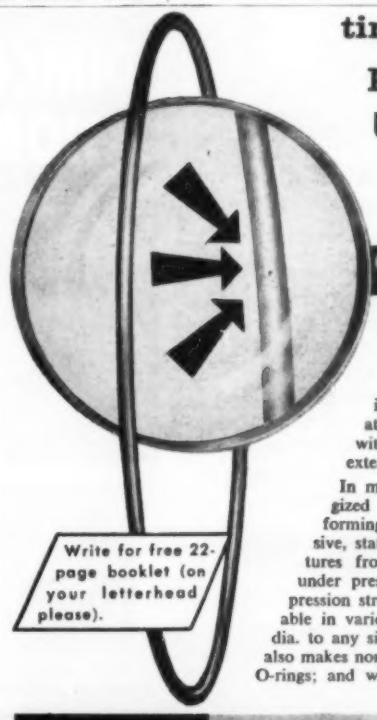
(F-106) Welded Metal Bellows—Catalog, 20 pp. Covers design procedures, material selection and applications, with slide calculator. The Belfab Corp, Municipal Airport, Daytona Beach, Fla.

(F-107) Lightweight Conical Joint—Brochure, 16 pp. Describes construction and applications; gives engineering information, test results, typical dimensions and ordering information. Marman Div, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles, Calif.

(F-108) Self-lubricating Powder Metal Bearings—Brochure, 4 pp. Describes economics and engineering of bearings. Data on properties, recommended uses and selection. Amplex Div, Chrysler Corp, PO Box 2718, Detroit 31, Mich.

(F-109) Viscous Torsional Vibration Dampers—Brochure, 4 pp. Lists range of sizes available for damping crankshaft torsional vibration; includes technical description and data requirements sheet. Houdaille Industries, Inc, Buffalo Hydraulics Div, 537 E Delavan Ave, Buffalo 11, NY.

(F-110) Push-pull Controls—Catalog, 15 pp. Describes control and accessories, typical installations; gives test data, engineering and ordering information for ball bearing flexible remote type. Controlex Corp of America, Box 511, White Plains, NY.



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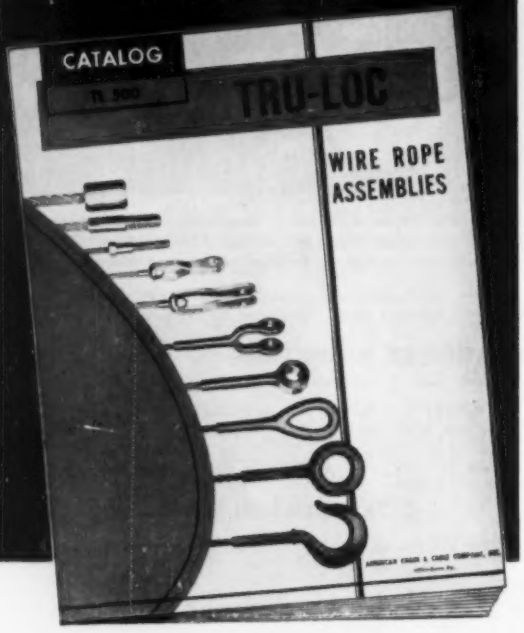

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(F-111) Flexible Couplings—Catalog, 10 pp. Includes typical dimensions, materials, specifications and drawings of couplings and component parts. Marman Division, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles, Calif.

(F-112) Heavy-duty Coil Springs—Catalog, 48 pp. Gives production range for hot-wound coil springs, steel grades, formulas, symbols, design principles, performance data and specifications. Crucible Steel Co of America, PO Box 2518, Pitts 30, Pa.

(F-113) Vibrating Screens—Catalog, 48 pp. Describes and illustrates different types of vibrating screens and foundry shakeouts as they are used to meet particular operating conditions; material characteristics capacities and accessories are also described. Link-Belt Co, Prudential Plaza, Chicago 1, Ill.

(F-114) Universal Joints—Bulletin, 4 pp. Describes design features and provides dimensions, operational drawings and sales information. Marman Div, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles, Calif.

(F-115) Metal Bellows and Assemblies—Catalog, 32 pp. Contains data on assembly, dimensions, pressure and stroke ratings, forming and application of one-piece expandible member formed into folded or corrugated unit. Includes charts, tables and graphic presentation of vapor-pressure-temperature relationships of charging liquids. Fulton Sylphon Div, Robertshaw-Fulton Controls Co, Knoxville 1, Tenn.

(F-116) Rotary Shock Absorber—Brochure, 8 pp. Explains operating principles; lists sizes, capacities, method of application and performance curves. Also includes photographs, and other selection aids. Houdaille Industries, Inc, Buffalo Hydraulics Div, 437 E Delavan Ave, Buffalo 11, NY.

(F-117) Continuous Vacuum and Pressure Filters—Bulletin, 8 pp. Describes line of equipment for filtration, operating conditions and applications of various types. The Eimco Corp, PO Box 300, Salt Lake City 10, Utah.

(F-118) Industrial and Commercial Filters—Catalog, 4 pp. Lists filters and applications. Gives working pressure, housing and material data. Dollinger Corp, 11 Centre Park, Rochester, NY.

(F-119) Rotation Joint—Bulletin, 4 pp. Describes construction, applications, capabilities and component parts together with cross section and installation drawings. Marman Div, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles, Calif.

(F-120) Roller Bearings—Catalog, 84 pp. Gives dimensions, load ratings, weights and other selection data with typical application prints on thrust, clutch release, cylindrical roller bearings and mounted units. Aetna Ball and Roller Bearing Co, Div of Parkersburg-Aetna Corp, 4600 Schubert Ave, Chicago 39, Ill.

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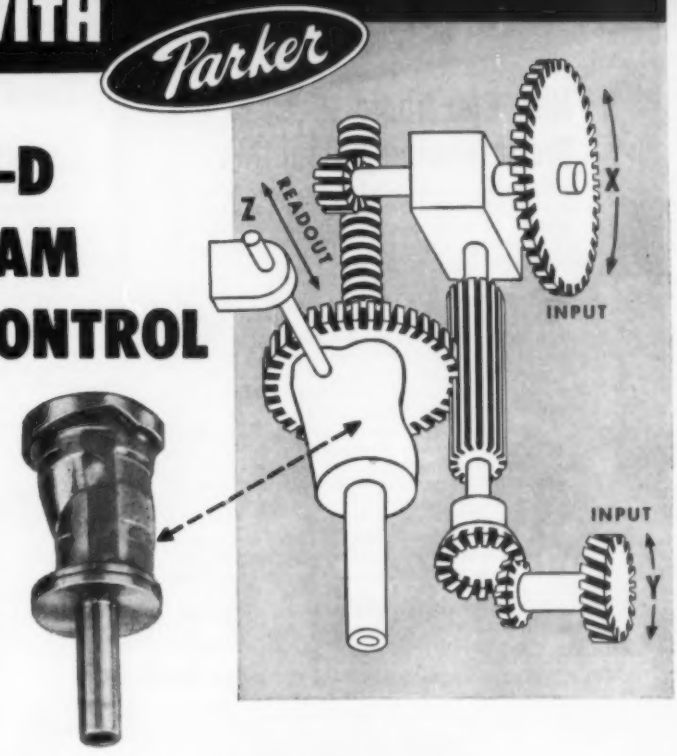

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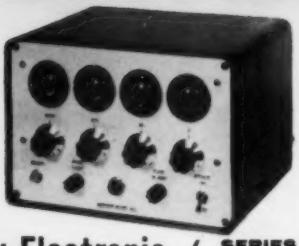

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This is your complete package for predetermining counting at high speeds.

For complete details on these units, write today!

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Instant quick-lever reset, plus quick and easy setting of the predetermined number are outstanding features of this counter. Measures approximately 2.6″ wide, 5″ long, 2.8″ high. Speeds up to 6,000 RPM or 8,000 CPM are maximums recommended.

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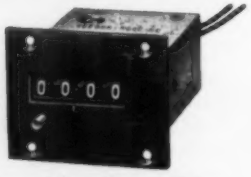

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Available for 6, 12, 24, 48 and 115 volts D.C. operation. For A.C. operation suitable electrical components must be added externally. Reset voltages available are 6, 12, 24, 48, 115 and 230.

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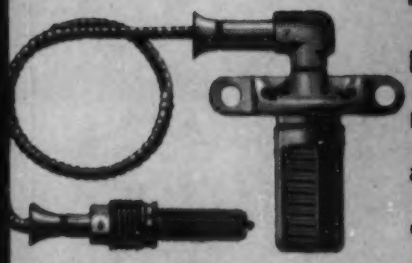

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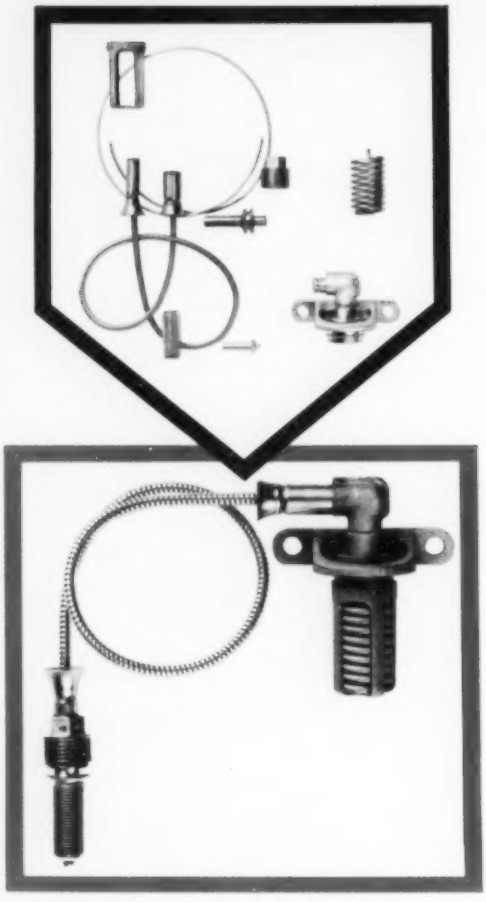

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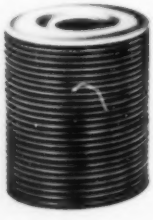
In one custom-engineered, pre-assembled "package", you can now obtain hydraulically formed or welded metallic bellows and all assembly components from Robertshaw . . . at a definite saving. Packaged Bellows are designed, produced, assembled and tested right in our modern plant, and delivered to you ready for installation. You save on handling, assembling, inspections, testing and paper work.

No other bellows supplier can offer you such a wide range of bellows metals and alloys . . . including titanium, zirconium, Hastelloys, Inconel-X, Monels, stainless steels and all the standard bellows metals. Bellows sizes are available from miniature ¼" O.D. up. If your applications require it, Robertshaw can supply Packaged Bellows for operation in the range of 1000°F plus and above 3000 psia pressure. Proper selection of metals, plus precision manufacturing, can also give you the resistance to corrosion and vibration that your tough applications demand.

Write for Bellows Bulletin 10 giving typical application data!



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FORMWELD BELLOWS

for premium performance!

Welded of any suitable weldable material, including many of the newer metals and alloys, to give you much greater adaptability to extreme environmental and service conditions. Closer control of bellows tolerances than ever before possible now assures greatly improved accuracy, predictable performance and longer life. Write for Bulletin 70!

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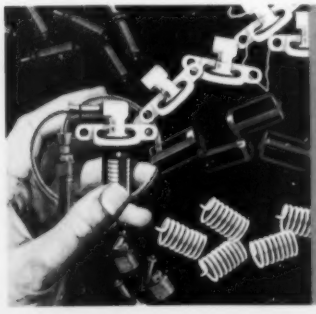
Save vital space and weight in aircraft, instrumentation and other equipment with hydraulically formed Robertshaw seamless metallic bellows as small as ¼" O.D. and 5/16" O.D. Custom-engineered in many metals to give you the exact characteristics you need. Write for Bulletin 10!



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N/D CASE HISTORIES

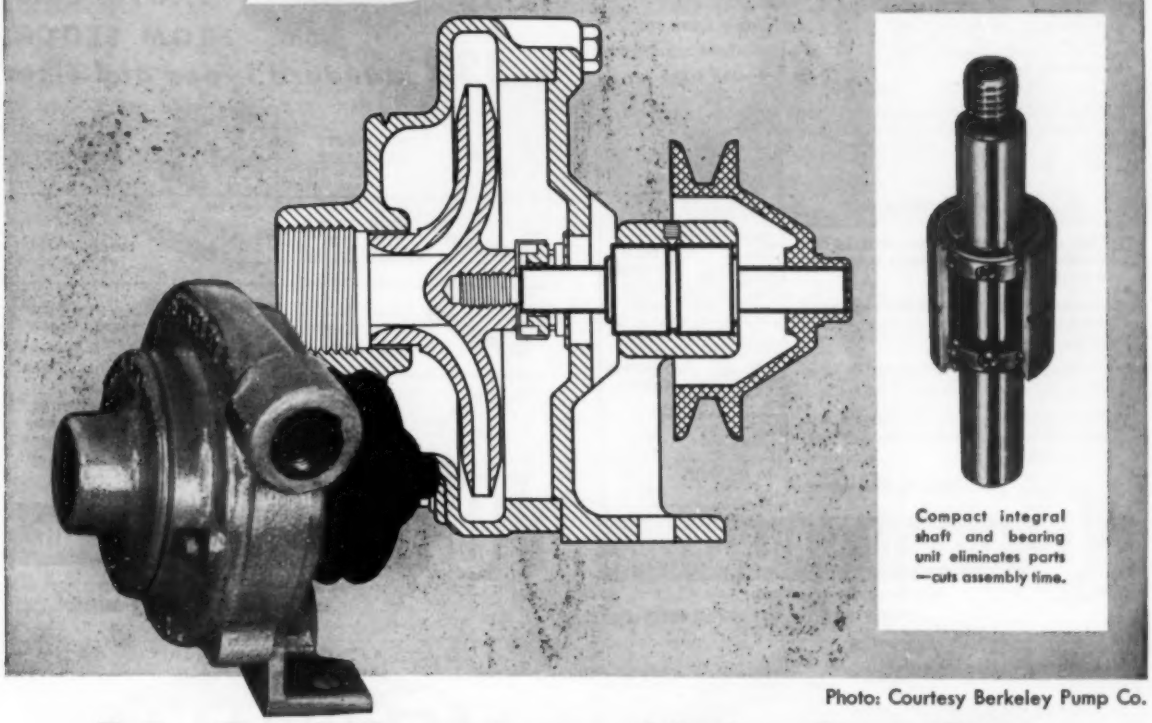


Photo: Courtesy Berkeley Pump Co.

N/D Ball Bearings Help Cut Size... Lower Costs $2.50 Per Pump!

CUSTOMER PROBLEM:

Redesign utility water pump for Air Conditioner market. Conversion must achieve smaller size without reducing pump capacity. At the same time, customer must lower over-all production costs.

SOLUTION:

N/D Sales Engineer suggested the versatile New Departure fan and pumpshaft ball bearing. This compact precision bearing permitted use of over-the-housing pulleys with belt load located over the raceway. Its integral shaft, which is the inner race, simplified design and helped reduce housing size without changing pump capacity. In addition, the sealed and lubricated-for-life bearing replaced two sealed bearings, separate shaft and snap rings . . . cutting part and assembly-time costs $2.50 per pump.

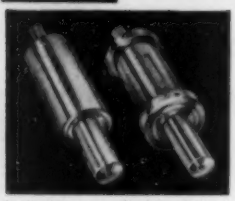
Perhaps one of New Departure's wide selection of *production* ball bearings will help give *your* product the sales appeal and cost savings you're looking for. For more information, call the New Departure Sales Engineer in your area or write Dept. P-9.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL



(*Left*) plain type. (*Right*) with longitudinal positioning nuts. Both are shown with BLANK SPINDLE END for machining by user.

Gilman CARTRIDGE-TYPE SPINDLE ASSEMBLIES

. . . available from stock in **28** *standard types and sizes*

AVAILABLE in plain cylindrical type or with longitudinal positioning nuts. Five types of spindle noses are offered. Range of cartridge diameters from 1.250" to 2.750".

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- Steel spindles are precision machined and ground, with close tolerances maintained throughout.
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- Positioning nuts are graduated in increments of spindle adjustment of 0.001".
- Spindle assemblies can be mounted in a bored hole or in Gilman precision mounting brackets.

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Gilman PRECISION SLIDE ASSEMBLIES

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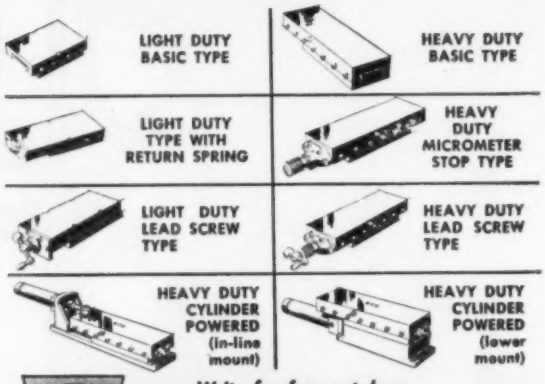
LIGHT DUTY BASIC TYPE
HEAVY DUTY BASIC TYPE
LIGHT DUTY TYPE WITH RETURN SPRING
HEAVY DUTY MICROMETER STOP TYPE
LIGHT DUTY LEAD SCREW TYPE
HEAVY DUTY LEAD SCREW TYPE
HEAVY DUTY CYLINDER POWERED (in-line mount)
HEAVY DUTY CYLINDER POWERED (lower mount)

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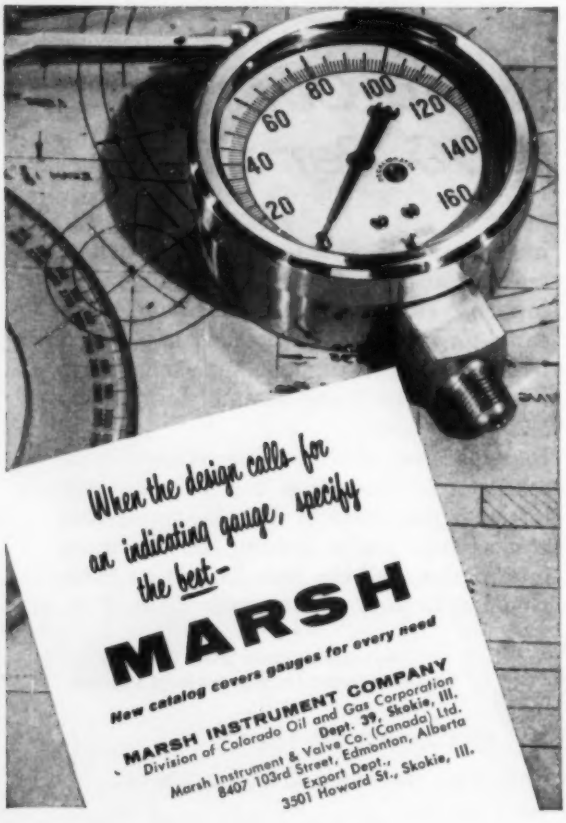
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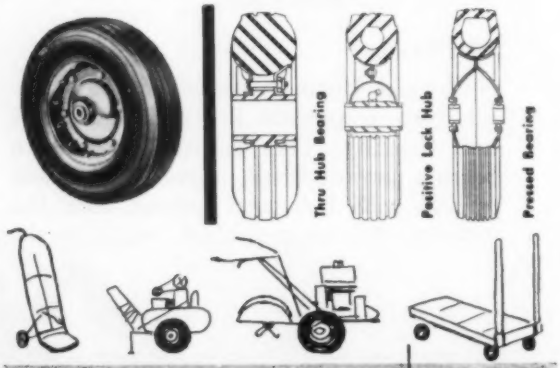

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catalogs and bulletins.....continued

(F-121) V-band Couplings—Catalog, 44 pp. Contains information on the function, selection, specifications and design of v-band couplings. Marman Div, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles, Calif.

(F-122) Jewel Bearings—Catalog, 20 pp. Describes materials, designs, applications, specifications, mounting and standard sizes of typical stock jewels. Richard H Bird & Co, Inc, 1 Spruce St, Waltham, Mass.

(F-123) Self-lubricating Iron Bearings—Brochure, 4 pp. Gives performance data, properties, recommended uses and discussion material on the economics of operation. Amplex Div, Chrysler Corp, PO Box 2718, Detroit 31, Mich.

(F-124) Sliding Journal Bearings—Catalog, 4 pp. Oil and water lubricated bearings for motors, gears, pumps, turbines, compressors and marine equipment. Waukesha Bearing Corp, Commerce & Pearl Sts, Waukesha, Wisc.

(F-125) Band Clamp—Catalog, 28 pp. Gives materials, dimensions, actual size drawings, strength charts, nut coding and approximate weights. Marman Div, Aeroquip Corp, 11214 Exposition Blvd, Los Angeles, Calif.

(F-126) Small Parts for Industry—Catalog, 10 pp. General descriptions and photographs of various types of parts including gears, coil bobbins, fasteners, special design, and parts for hardware, clothing, jewelry, and model-makers. Both zinc die castings and molded plastic parts are included. Gries Reproducer Corp, 125 Beechwood Ave, New Rochelle, NY.

(F-127) Roller Bearing Bushings—Catalog, 6 pp. Describes applications on jigs, fixtures and horizontal milling machines; gives engineering data, performance reports, sizes and ordering data. Jergens Div of Donley Products, Inc, 11106 Avon Ave, Cleveland 5, Ohio.

(F-128) Metal Bellows and Assemblies—Bulletin, 6 pp. Illustrates construction and application of various hydraulically formed and welded bellows. Compares construction features. Robertshaw-Fulton Controls Co, Bridgeport Thermostat Div, 155 Hill St, Milford, Conn.

(F-129) High-Speed Cam Indexing Mechanisms—Catalog, 16 pp. Describes roller gear drive indexing mechanisms for achieving intermittent and oscillating motions. Rated for speeds up to 2000 indexes per minute with precision of .001 in. and zero backlash for 8000 to 20,000 hours operation. Data on installation design and calculation of load requirements is included. Ferguson Machine Corp of Indiana, 7818 Maplewood Industrial Court, St Louis 17, Mo.

(F-130) Slip Ring Assemblies—Catalog, 12 pp. Charts on ring construction, usage, specifications, facilities and data required for design. Engelhard Industries, Inc, 113 Astor St, Newark, NJ.

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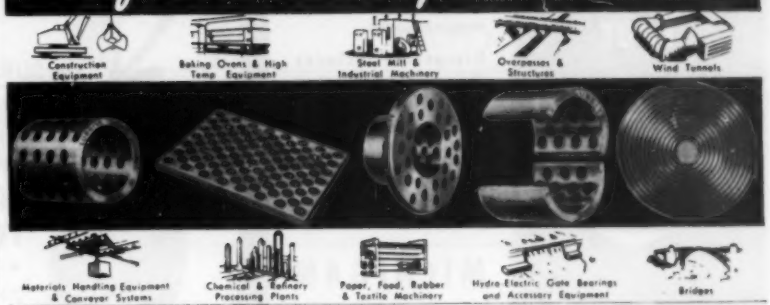
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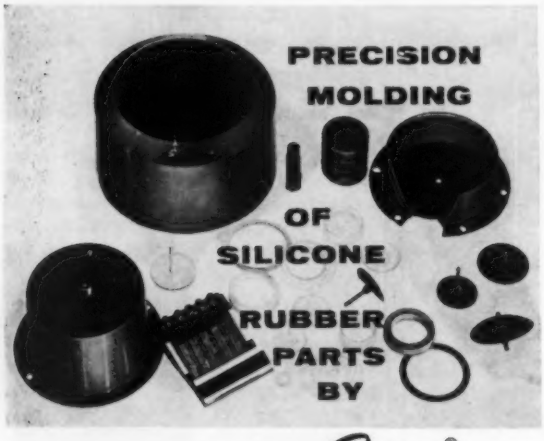

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catalogs and bulletins.....continued

(F-131) Metal Gaskets—Bulletin, 4 pp. Describes construction and applications of noncompressible, close tolerance metal gaskets with pressure sensitive surfaces for difficult static sealing applications. Presswork Inc, 9100 Roselawn, Detroit 4, Mich.

(F-132) Pneumatic Wheels—Catalog, 24 pp. Pneumatic wheels to Mil-W-8005 and commercial standards, and their application in ground support equipment articles. Saginaw Products Corp, 68 Williamson St, Saginaw, Mich.

(F-133) Hydraulic Filters—Bulletin, 10 pp. Covers sump and line types. Describes applications, construction; gives dimensions, engineering data, sizes and ordering information. Capital Engineering & Mfg Corp, 5837 S Ashland Ave, Chicago 36, Ill.

(F-134) Plate and Groove Cams—Catalog, 8 pp. Standard plate cams are listed by stroke, timing and load rating. Discusses physical designs, application and installation. Graphs showing relationship between stroke, minimum movement time and size of cam blank are provided to simplify cam selection. Ferguson Machine Corp of Indiana, 7818 Maplewood Industrial Court, St Louis 17, Mo.

(F-135) Self-aligning Bearings and Rod Ends—Catalog, 36 pp. Bore sizes from ⅛ in. to 6 in. in dia, ultimate loads to 893,000 lbs, two-piece construction are features of plain and rod end bearings. Southwest Products Co, 1705 S Mountain Ave, Monrovia, Calif.

(F-136) Heat Transfer Coil System—Catalog, 20 pp. Gives construction materials, heating and cooling media, typical installations, sizes, surface data and maximum operating pressures. Includes capacity tables, performance curves and photographs. Tranter Mfg, Inc, 735 E Hazel, Lansing 9, Mich.

(F-137) Bellows—Catalog, 8 pp. Series of fusion-welded metal diaphragms with an edge on each end which, when matched with a similar edge on a fitting, can be fused together. Gives specifications for flexible, pressure and expansion types. Breeze Corporations, Inc, 700 Liberty Ave, Union, NJ.

(F-138) Deep-groove Ball Bearings—Bulletin, 12 pp. Provides dimensions, load capacities and other application data for standard width deep-groove series bearings, including open, shielded and teflon contact seal types. Cartridge and felt seal bearings are also offered. Hoover Ball and Bearing Co, 5400 S State Rd, Ann Arbor, Mich.

(F-139) Automotive and Actuator Products—Catalog, 19 pp. Diameters, assembly data, specifications, design characteristics, size range and ordering data of ball bearing screws and splines for linear positioning. Saginay Steering Gear Div, General Motors Corp, 3900 Holland Rd, Saginaw, Mich.

EXTRA-THIN BEARING WITH BUILT-IN SHIELDS

- SAVES SPACE
- SIMPLIFIES ASSEMBLY
- CUTS MAINTENANCE COST

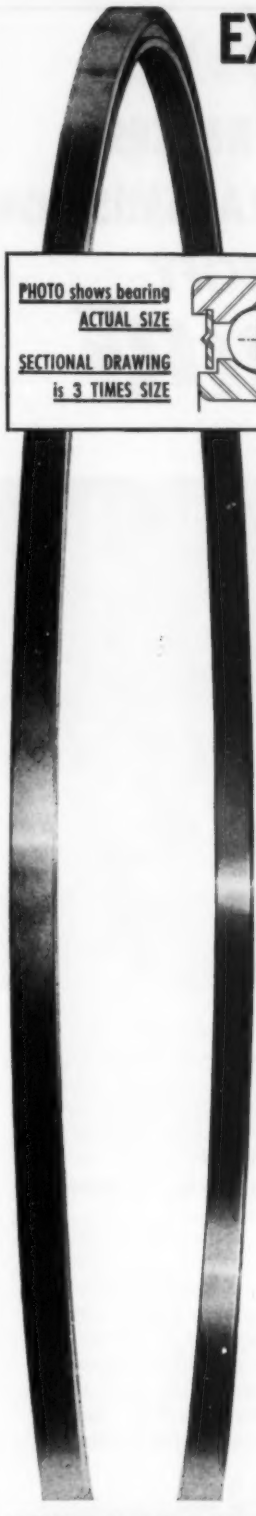

PHOTO shows bearing ACTUAL SIZE

SECTIONAL DRAWING is 3 TIMES SIZE

SIZE: 10.500″ OD; 0.270″ wide; 0.250″ thick.
BALL DIAMETER: 0.125″ ±.000025″.
MATERIALS: Stainless steel.
MAXIMUM RUNOUT OF OUTER RACE: 0.0002″ TIR.
STATIC LOAD CAPACITY: Radial, 4,630 lb.; axial, 13,200 lb.
TORQUE: 5 to 6 inch-ounces at 100 lb. axial load.

Standard bearings often impose limitations on production economy and freedom of design. These restrictions are often eliminated by *special* bearings, custom-engineered by ITI. For example—

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FREE BULLETIN AFB-2 describes our work in this field—shows a wide variety of "specials"—tells about factors involved in special bearing applications. Write for it!

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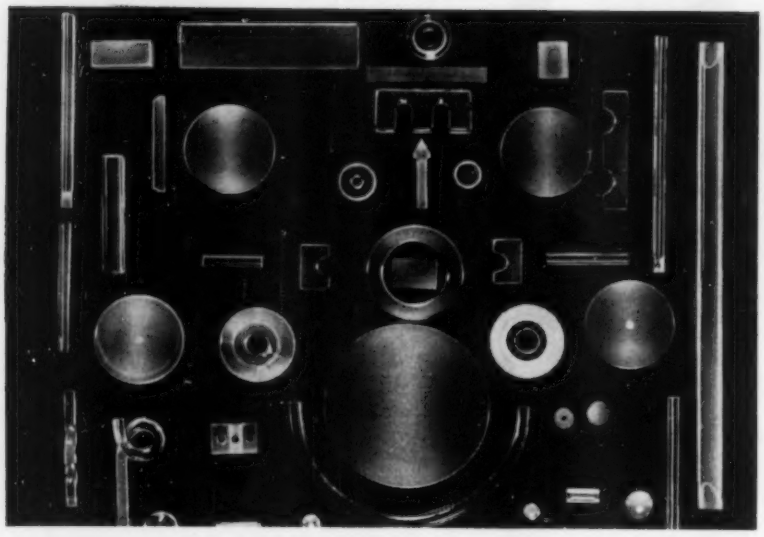

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E MECHANICAL PARTS AND DESIGN ANALYSIS

catalogs and bulletins.....continued

(F-140) Push-pull Controls—Catalog, 72 pp. Gives sizes, load capacities, diameters, operation and application information for connector, locking, lever, converter and other push-pull controls. Arens Controls, Inc, 2017 Greenleaf St, Evanston, Ill.

(F-141) Bushings, Oilless Bearings and Slip-ring Assemblies—Catalog, 60 pp. Dimensions, typical values, construction materials, applications and inquiry form. Graphite Metallizing Corp, 1022 Nepperhan Ave, Yonkers, NY.

(F-142) Pillow Blocks and Flange Units—Bulletin, 12 pp. Contains dimensions of pillow blocks and flange units; load ratings of prelubricated sealed bearings and interchangeability tables. Marlin-Rockwell Corp, 402 Chandler St, Jamestown, NY.

(F-143) Power Springs—Catalog, 20 pp. Descriptive and technical data on spiral and crosscurred power springs for wide range of applications. Special stainless alloy springs for instruments, timing and recoil mechanisms. Sandvik Steel Inc, 1704 Nevins Rd, Fair Lawn, NJ.

(F-144) Spherical Roller Bearings—Catalog, 49 pp. Describes design, manufacture, packaging and maintenance of self-aligning roller bearings, locknuts, washers and sleeves. The Torrington Co, 59 Field St, Torrington, Conn.

(F-145) Bearings—Catalog, 32 pp. Description of spherical self-aligning bearings, lubrication and mounting information, listing of distributors, engineering data and drawings. The Heim Co, 46 Sanford St, Fairfield, Conn.

(F-146) Roller Bearings—Catalog, 48 pp. Includes dimensions, load ratings, shaft and housing tolerances on needle bearings, cam followers, journal and thrust roller bearings. Orange Roller Bearing Co, Inc, 557 Main St, Orange, NJ.

(F-147) Torque Limiting Devices—Catalog, 8 pp. Gives descriptions, specifications and dimensions of spring plungers, ball plungers, and others. Vlier Engineering Corp, 8900 Santa Monica Blvd, Los Angeles 46, Calif.

(F-148) Push-pull Controls—Catalog, 8 pp. Describes compression and tension type mechanical push-pull controls. Performance data, typical diameters and minimum bend radius figures are given for various sizes. Southwest Products Co, 1705 S Mountain Ave, Monrovia, Calif.

(F-149) Metal Bellows Seal—Bulletin, 4 pp. Describes operating ranges, space envelope standards and gives typical applications for special end face seal. Chicago Rawhide Mfg Co, 1301 Elston Ave, Chicago, Ill.

(F-150) Roller Bearings—Catalog, 104 pp. Dimensions, capacities, fits and tolerances of standard and special bearing types. Includes description of manufacturing facilities. Roller Bearing Co of America, Sullivan Way, W Trenton, NJ.

exceptionally close limits...

The photograph shows the connecting rod of an unusual hydraulic pump built by a company whose name is known everywhere.

The finish in the bore of both the large hole and the small hole must be held to very fine profilometer reading.

In addition, the axes of these two holes must be parallel to each other within exceptionally close limits. Naturally, the user of a cast bronze part such as this turns to Bunting in order to assure strictest adherence to his print and specifications.

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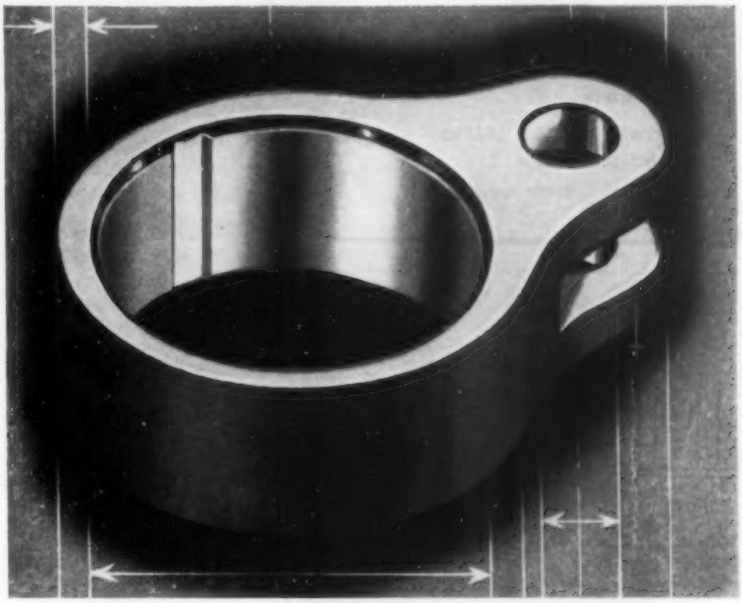

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catalogs and bulletins . . . . . continued

(F-151) Rotaly Positioning Controls—Bulletin, 4 pp. Capable of controlling loads from inch ounces to 200 lbs; designed for applications as no-back devices, valve and potentiometer positioners, clutches, couplings, and other uses. Reid Controls, Reid Metal Products, Inc, 2021 N Lincoln St, Burbank, Calif.

(F-152) Push-pull Controls—Catalog, 15 pp. Describes push-pull control construction, possible applications, methods of control seletcion, operational features and dimensions. Permits continuous or intermittent transmission of reciprocal motion Automotive and Aircraft Div, American Chain & Cable Co, 601 Stephenson Bldg, Detroit, Michigan.

(F-153) Buffing Equipment—Catalog, 30 pp. Gives specifications, dimensions, operational data, discount schedule and prices for various models. Also contains section on buffing compounds. H W Kramer Co, Inc, 120-30 Jamaica Ave, Richmond Hill, NY.

(F-154) O-ring and Seals—Catalog, 52 pp. Engineering data on the design and application of o-ring hydraulic packings with tables showing groove designs. Information on the use of o-rings as flange seals, rotating shaft seals, and other applications. Cross reference chart and tables describing compounds for specific types of service. Precision Rubber Products Corp, 3110 Oakridge Drive, Dayton, Ohio.

(F-155) Hydraulic and Air Service Packings—Catalog, 9 pp. Prices and pressure recommendations for fluid seal pistons, cups and nonadjustable packings. Lubrikup Co, Inc, PO Box 386, Williamsport, Pa.

(F-156) Sound Analysis—Brochure, 17 pp. Describes basic instrumentation, measurement, analysis and control of noise including descriptions of available equipment. H H Scott, Inc, Instrument Div, 111 Powder Mill Road, Maynard, Mass.

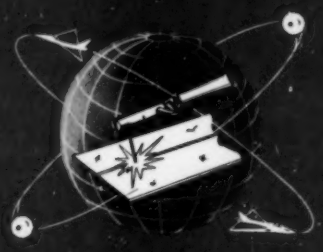
(F-157) O-rings—Brochure, 20 pp. Describes available compounds, general properties of natural and synthetic rubbers and typical applications. Provides cross-reference charts of o-ring size and part numbers. Specific size and installation data on aircraft and industrial type seals is included. The Auburn Mfg Co, Middletown, Conn.

(F-158) Leather and Synthetic Rubber Packings—Catalog, 46 pp. Contains line drawings, specifications and applications for pneumatic and hydraulic equipment. Albert Trostel Packings, Ltd, Lake Geneva, Wisc.

(F-159) Piston Packing Material—Bulletin, 16 pp. Describes textures, operating pressures and temperatures, recommended uses and prices of cups and pistons as well as the packing materials. Also includes photographs and selection aids. Darling Valve & Mfg Co, Walnut St, Williamsport, Pa.

SECTION G

FASTENING AND JOINING



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DESIGN ABSTRACTS

BRAZING DISSIMILAR METALS

During a brazing cycle, the parts being joined expand while they are being heated and then attempt to return to their original dimensions when the assembly cools down. When all parts of the assembly are made of the same metal, they change dimensions at the same rate (assuming equal heating and cooling rates) so that the joint clearance remains constant during the entire cycle. However, when the assembly contains dissimilar metals, the joint clearance may change substantially from room temperature to brazing temperature.

Clearance

In such a joint, if a high-expanding metal surrounds a low-expanding metal, the clearance, which was nominally correct at room temperature, may become so enlarged at brazing temperature that the filler metal cannot fill the joint gap.

Calculations cannot be used to select exact clearance required, nor do they eliminate trial brazes entirely, but they do permit some useful predictions about what will happen to the initial clearance when parts are heated to brazing temperature.

"Predicting Gap Change Reduces Trial Runs in Brazing Dissimilar Metal Joints," D C Herschaft, Handy & Harman; Welding Journal, Mar '59; 33 W 39th St, New York 18.

*

Design for Welding

The three predominant undesirable approaches to designing for welding are discussed: (1) attempting to maintain traditional physical structure as developed through previous fabricating procedures; (2) designing extremely lightweight structures without adequate precautions against localized buckling or nonelastic deformation—particularly when caused by inadequate dimensional stability or resistance to vibration effects; (3) designing only with plate, bar or shaped stock instead of employing composite approaches, involving castings, forgings, pressings.

Suggestions are given on avoiding excessive welding costs, determining minimum distance between joints, calculating design factors at bends, comparison of labor costs for certain processes. Vibration damping, buckling problems, joint design are also discussed.

"Design for Production by Welding," John Mikulak, Worthington Corp; Welding Journal, Sept '58, 29 W 39th St, New York 18.

*

Load in Screw Threads

This critical review of papers on distribution of load includes comments on the work of Sopwith, Atkin, Case, Arnold, Atkins, Buckingham, Stewart, Hill, Hetenyi, Goodier.

Abstracted from "Critical Review of Distribution of Load in Screw Threads," B H Vidugiris, Case Institute of Technology, Fasteners, Vol 13, No 2, Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13.

*

Solderability of Wire

An apparatus that performs a "spread" test is illustrated. Investigations of solderability based on this testing device are described.

"An Apparatus for Testing Solderability of Wire," J A ten Duis, Philips Technical Review, Dec '58, N V Philips Gloeilampenfabrieken, Eindhoven, Holland.

*

Silver Brazing

Silver brazing has become widely accepted as a versatile production method for joining metal components, and this method can offer many advantages if the decision to employ it is taken at the design stage. Provided that the designer is fully conversant with fundamental silver brazing principles, he is able to include certain simple features in the design of components that will greatly facilitate the brazing operation, resulting in sound high-strength joints together with reduced production costs.

The position gained by silver brazing in mass production assembly may be attributed largely to the low temperatures involved, thus shortening the heating stage, which results in time saving. Where sheet components are concerned, low brazing temperatures lead to less distortion, which will usually mean a reduced treatment in later assembly. Further economy is achieved in finishing for the neat fillet formed around the joint often requires no dressing. This article further outlines the ways in which the process can be exploited and emphasizes the need to design specifically if its best features are to be achieved.

"Design Factors in Silver Brazing," L D Connell, Johnson, Matthey & Co Ltd; Engineering Materials and Design, Nov '58, Drury House, Russell St, London, WC2.

*

Determining Weld Size

A five-step method for determining required weld dimensions for various types of welds and applications is presented. Suggestions are based on American Welding Society definitions and stress allowances.

"Practical Approach to Determine Weld Size," O W Blodgett, Lincoln Electric Co, AWS paper 12-C, 33 W 39 St, New York 18.

*

Assembly Methods

Low-cost, efficient and ingenious assembly of products accounts for much of our success as an industrial nation. Yet the search is always on for even better assembly methods, whether to reduce costs or improve reliability. As in most engineering progress, the process of finding the better method is one of evolution.

But to spark the inventive processes

that yield the new idea there must usually be a catalyst; two or more assembly methods—even though quite different—can then combine to produce a completely new and better method. The catalyst in all design-engineering problems is experience and recallable knowledge.

A treasurehouse of material dealing with assembly has appeared in the pages of PRODUCT ENGINEERING. It represents the combined experience of many top engineers. This valuable material, plus ideas and suggestions from many companies, has been distilled and is presented in a special report. It provides both a solid package of practical how-to's, and the catalyst for further progress through new ideas.

"Assembly Methods . . . An Engineering Roundup," Douglas C Greenwood, Product Engineering, June 8, '59, 330 W 42nd St, New York 36.

*

Blind Rivets

A selection of 29 commercially available and "home-made" devices that allow mechanical joints to be made from only one side of an assembly.

"29 Blind-side Fasteners," F Strasser; Product Engineering, 330 W 42nd St, New York 36.

*

Three New Welding Electrodes

Three new electrodes have been developed for high-strength weldments that will respond to heat treatments such as are used in aircraft. Tests show that the weld metal matches hardness and tensile strength of the base at tempering temperatures between 450 and 1250 F.

The prevailing approach to composition of steel weld metal considers that all steel is low-carbon type with or without alloy additions. The weld metal is expected to meet all the mechanical properties required of it regardless of base metal or heat treatment.

Steels used in welded fabrication can conveniently be divided into three groups: Low-carbon or mild steel (less than 0.25% C); medium-carbon (0.25 to 0.45% C); and high-carbon grade (above 0.45% C). The greatest tonnage comes from the first group.

Electrode Requirements

Since mild steel is easiest to weld, a large variety of electrode types are available. Also, light and medium mild steel sections generally do not require preheat or postheat treatments.

The medium-carbon steels require more specialized electrodes, perhaps containing a small amount of alloy. They also call for greater welding skill, generally some preheat—the amount varying with the carbon content of the base metals and section thickness.

The high-carbon group requires even more specialized electrodes, greater skill and higher preheat and a postheat treatment.

"Three New Low-Hydrogen Iron-Powder Electrodes" D C Smith and W G Rinehart, Harnischfeger Corp; Metal Progress, Feb '59, 7301 Euclid Ave, Cleveland 3.

*

Specifications for Nuts

Reasons for use of separate specifications for nuts, rather than all-inclusive specifications for the fastener assembly, are given. Critical factors are discussed and suggestions for writing the specification are included.

"Why Nuts Should Have Their Own Specifications," J S Davey, Russell Birdsall and Ward Bolt & Nut Co, Industrial Fasteners, Vol 13, No 3, 1517 Terminal Tower, Cleveland 13.

*

Stress of Threaded Fasteners

The results of a survey of 800 publications conducted by Case Institute of Technology for Industrial Fasteners Institute are described. The study was devoted to nuts and bolts—with the emphasis on nuts. Major classifications used were: load distribution, bolt fracture, thread stripping, nut height and material. Some 30 references are included in this article.

"Literature Search on Stress Analysis of Threaded Fasteners," Fasteners, Vol 13, No 4, Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13.

*

Fastenings

A survey (in German) of types of fastenings is presented and a simple system for relating virtually all types and classes is developed.

"Survey of Fastenings," W Bischoff, Technical Univ of Ilmenav (E Germany), Feingerateleschnik, Sep '58, 12 Unter den Linden, NW 7, W Berlin, Federal Republic of Germany.

*

Adhesive Bonding

Faster output, lower labor and material costs are the three main reasons why adhesive bonding is today replacing welding, brazing, soldering and mechanical fasteners in many different types of metal-working applications

There are, however, literally hundreds of different types of adhesives available, each formulated to do a specific bonding job on materials that vary from ceramics to steel plate. There are, too, many other variables involved in adhesive bonding—the end use of the product and parts configuration, for example.

Because adhesives are just coming into wider use and creating brand new production techniques as their applications extend, and because of the bewildering variety of adhesives, this article has been compiled as a basic guide.

"The Production Man's Guide to Adhesive Bonding Methods," John P. Wright, Metal-working Production, Aug 1 '58, 95, Farringdon St, London, E.C.4, England.

From: American Machinist

Common Thread-fit Problems

This helpful guide to the specific causes of thread misfits, their symptoms and means of detection was compiled jointly by the three SPS Screw Thread Metrology Laboratories at Jenkintown, Cleveland, and Santa Ana, Calif., where problems on screw thread fits are solved for industry.

JOHN B. TWINING
Chief Metrologist, Screw Thread Metrology Laboratory, Standard Pressed Steel Co. Jenkintown, Pa.

Possible Cause	Detection	Accuracy Direct Reading to:
	Bolts Loosen in Tapped Hole	
(a) External thread PD is to low	(a), (c) Measure pitch dia on 3-roll gage	0.0001
(b) Internal hole is oversize	(a), (c) Check major dia with micrometer or super-mike	0.0001
(c) Tapered threads	(b), (c) Check tapped hole with thread plug gage or internal thread comparator	0.0001
(d) Incorrect preload	(b) Check minor dia with plain plug or an internal micrometer	Plus functional gage fit
	(d) Check proper installation	
	Binding in a Tapped Hole	
(a) PD or major diameter oversize	(a), (c), (d) Measure PD on 3-roll gage set up (PD and functional)	0.0001
(b) Excessive lead error	(a), (d) Check major dia with micrometer or super-mike	0.0001
(c) Improper thread form	(b) Check lead on lead tester	0.00001
(d) Tapered thread	(c), (d) Thread form and lead by optical comparator	To 100X mag
	(c) Use form and radii charts	To 100X mag
	Thread Will Not Start	
(a) Distorted lead thread	(a) Check on optical comparator	To 100X mag
(b) Nicked lead thread	(a) Check with ring thread—also visual	Functional check
(c) Mating parts not same class or size of thread	(b) Visual check and use of ring thread	Functional check
	(b) Use of microscope	40X
	(c) Use of magnetic plating thickness gage, 3-roll gage or internal thread comparator	0.0001
	Loose or Sloppy Fit	
(a) Undersize PD	(a), (d) Use PD and Functional 3-roll gage	0.0001
(b) Mating parts not same class or size of thread	(b), (d) Internal thread comparator	0.0001
	(b) Ring thread and thread plug gages	Functional check
(c) PD of tapped hole is oversize	(c) Thread plug—internal thread comparators	Functional check
(d) Tapered thread	(c) Three-wire check with mold of tapped hole	0.0001
	Low Torque When Used With Locknut	
(a) Locking feature of nut will not meet torque requirements (on standard studs)	(a) Use of torque wrench and standard stud	inch oz
(b) PD of bolt is undersize	(a) Use of thread plug gage	Functional check
	(b) Use of PD and functional 3-roll gage	0.0001
	(b) Three-wire check	0.00001
	Excessive Torque When Used With Locknut	
(a) Locking feature of not will not meet torque requirements (on standard studs)	(a) Use of torque wrench and standard stud	inch oz
(b) PD of bolt is oversize	(a) Use of thread plug gage	Functional check
(c) Lack of lubricant on locknut	(b) Use of PD and functional 3-roll gage	0.0001
	(b) Three-wire check	0.00001
	(c) Visual inspection	Visual
	Galling Threads	
(a) Burrs	(a) Microscope check	40X
	(a) Use of ring thread	Functional check
(b) Excessive lead errors	(b) Use of lead tester	0.00001
	(b) Optical comparator	100X
(c) Materials prone to galling—not properly plated	(c), (e) Chemical test (etching)	(To magnify laps)
	(c) Magnetic plating thickness gage	0.0001
(d) Poor surface finish on threads	(d) Use of surface roughness checker	1 micro inch
(e) Lapped threads	(d), (e) Use of microscope	40X

REFERENCE:
Common Thread-fit Problems. Published in *American Machinist*, Nov. 3. 1958, p. 121.

FASTENING AND JOINING G+

From: Welding Journal

Predicting Gap Change in BRAZING Dissimilar Metal Joints

Calculations permit some useful predictions about what will happen to the initial clearance when parts are heated to brazing temperature.

D. C. HERRSCHAFT, Assistant Manager
Brazing Products Division
Handy & Harman

During a brazing cycle, the parts being joined expand while being heated and attempt to contract to their original dimensions upon cooling. When all parts of an assembly are of the same metal, dimensions change at the same rate and the joint clearance remains constant. However, when joining dissimilar metals, the joint clearance can change substantially from room temperature to brazing temperature.

If a high-expanding metal surrounds a low-expanding metal, the clearance, which is nominally correct at room temperature, may become so enlarged at brazing temperature that the filler metal cannot fill the gap. Conversely, if the high expanding metal is on the inside, the clearance at brazing temperature may be reduced so much that the small amount of alloy drawn into the joint is either ruptured or highly stressed when the gap tries to enlarge upon cooling after brazing.

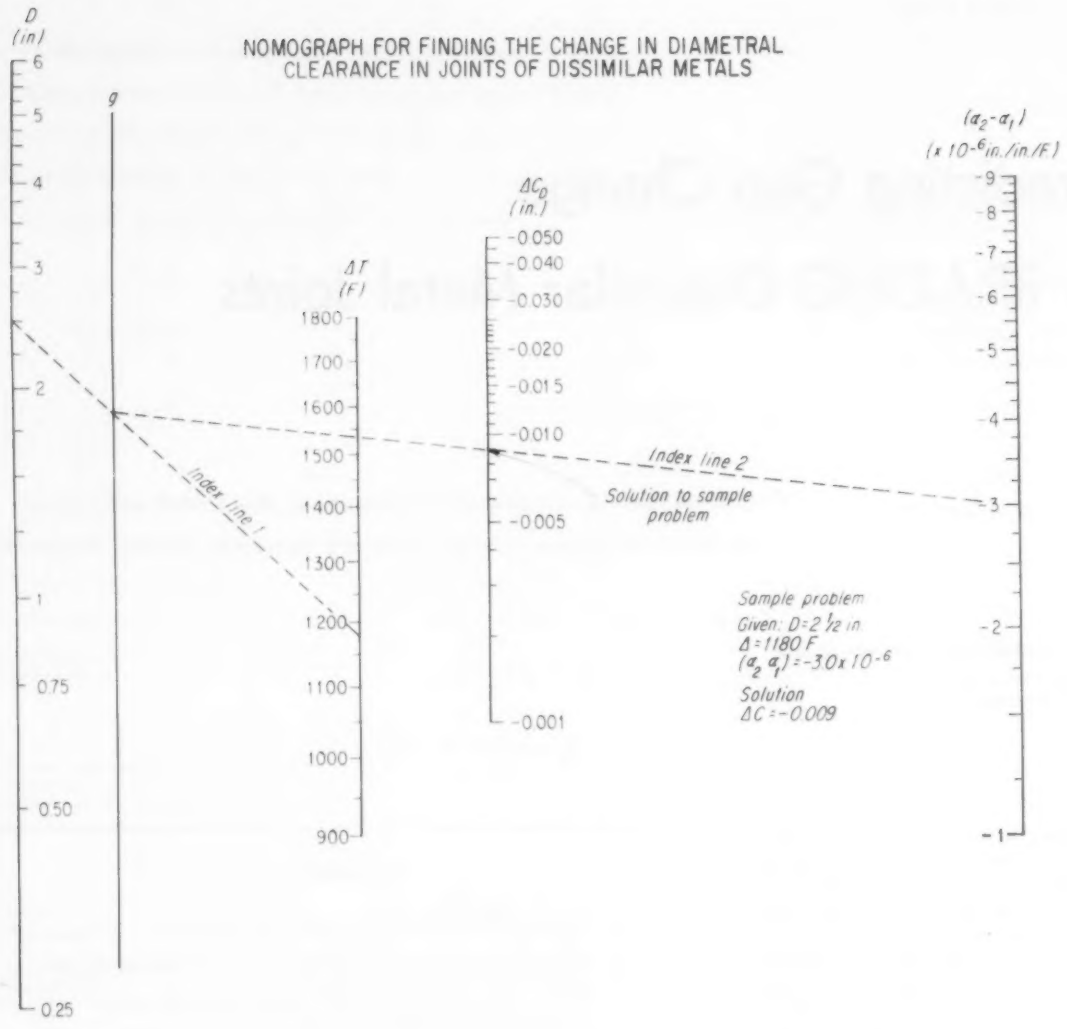
Normally, it is necessary to braze several sample joints having different initial clearances to determine a satisfactory clearance. Some simple preliminary calculations will minimize the number of trial and error samples required.

The calculations indicate whether the gap will expand or shrink and the approximate size of the change. From this, it can be surmised if the gap will be too large or too small to be brazed successfully and how much the alloy will be stressed if the gap tends to expand on cooling. The calculations help in selecting the initial clearance that will avoid excessive stress on the solidified brazing alloy.

The amount of stress the filler can safely withstand is difficult to predict because it is influenced by the duc-

Nomenclature

T_1 = room temperature, F
T_2 = solidus temperature of the brazing filler metal, F
$\Delta T = T_2 - T_1$
α_1 = mean thermal expansion coefficient of the male member over the temperature range ΔT, in./in./F
α_2 = mean thermal expansion coefficient of the female member over the temperature range ΔT, in./in./F
D_1 = outside diameter of the male member at room temperature, in.
D_2 = inside diameter of the female member at room temperature, in.
ΔD_1 = change in the diameter of the male member when heated to temperature T_2
ΔD_2 = change in the diameter of the female member when heated to temperature T_2



tility of both the base metals and the brazing alloy. As a rule, the filler metal should not be stretched much beyond 50% of its original thickness.

FORMULA FOR ESTIMATING CLEARANCE CHANGE

The general expression for the effect of temperature on the joint clearance is

$$\Delta D_2 = D_2\alpha_2\,\Delta T \qquad (1)$$

and

$$\Delta D_1 = D_1\alpha_1\,\Delta T \qquad (2)$$

Subtracting Eq (2) from Eq (1) gives

$$\Delta D_2 - \Delta D_1 = \Delta T(D_2\alpha_2 - D_1\alpha_1) \qquad (3)$$

$\Delta D_2 - \Delta D_1$ is the change in diametral clearance caused by heating the parts to temperature T_2. Letting $\Delta D_2 - \Delta D_1 = \Delta C_D$ = change in diametral clearance, Eq (3) becomes

$$\Delta C_D = \Delta T(D_2\alpha_2 - D_1\alpha_1) \qquad (4)$$

If α_2 is greater than α_1, ΔC_D is positive, but if α_2 is less than α_1, ΔC_D is negative. By convention, a positive sign indicates that the clearance is increasing; a negative sign indicates a decreasing clearance when the parts are heated to brazing temperature.

To further simplify the equation, it can be assumed that $D_1 = D_2$, or that the parts have no initial clearance at room temperature. Then Eq (4) is

$$\Delta C_D = D\,\Delta T(\alpha_2 - \alpha_1) \qquad (5)$$

where D is the nominal diameter.

Eq (5) is general and based strictly on the laws of linear expansion. It does not consider the elastic moduli of the base materials, the values of which definitely influence the magnitude of the residual stresses produced in the brazed assembly. A complete analysis based on the theory of elasticity is complex and the values in error since the materials behave plastically at higher temperatures.

TABLE I–Theoretical Percentage of Elongation in Filler Metal

(For various room temperature diametral clearances when ΔC_D = 0.020 in.)

Diametral Clearance at room temperature	Diametral Clearance at solidus temperature	Theoretical % elongation of filler metal on cooling
0.020	0.000	.....
0.030	0.010	200
0.040	0.020	100
0.050	0.030	66.7
0.060	0.040	50
0.070	0.050	40
0.080	0.060	33.3
0.090	0.070	28.6
0.100	0.080	25
0.110	0.090	22.2
0.120	0.100	20

To calculate the theoretical percentage of elongation, divide the absolute value of ΔC_D by the diametral clearance at solidus temperature and multiply by 100.

SAMPLE CALCULATIONS

The situation of most concern is where α_s is greater than α_r, since this will produce residual tensile stresses in the brazing alloy when the joint cools. Whenever possible, joints should be designed to place the brazing alloy in compression upon cooling.

Assume that a 3 in. dia yellow brass rod (65% Cu, 35% Zn) is to be brazed into a Type 416 stainless steel plate. It is necessary to select the initial room temperature clearance so that no more than a 50% theoretical enlargement of the joint gap upon cooling will occur.

For these materials

$$\alpha_2 = 6.50 \times 10^{-6} \text{ in./in./F}$$
$$\alpha_1 = 12.67 \times 10^{-6} \text{ in./in./F}$$

These are mean values for the steel plate and brass rod from 68 F to 1112 F (20-600 C). Assume that the joint will be brazed with a BAg-3 filler metal; solidus temperature is 1170 F. Then

$$\Delta T = T_2 - T_1 = 1170 - 70 = 1100 \text{ F}$$

and

$$\Delta C_D = D\,\Delta T(\alpha_2 - \alpha_1) = 3(1100)(-6.17 \times 10^{-6}) = -20361 \times 10^{-6} = -0.020 \text{ in.}$$

The results indicate that the diametral clearance will change by −0.020 in. when the parts are heated from room temperature to the solidus temperature of the brazing filler alloy. Thus, the initial diametral clearance must be greater than 0.020 in., otherwise there will be no gap for the brazing alloy to flow into at brazing temperature of the assembly.

The increase in gap size should be no larger than needed to produce a theoretical elongation of 50% in the filler metal upon cooling to room temperature. Theoretical elongation assumes that all the elongation occurs in the filler and none in the base metals. It is the per cent increase in joint gap found by dividing the net change (ΔC_D) by the clearance at solidus temperature.

Table I tabulates the theoretical percentages of elongation when various initial diametral clearances between the rod and plate are reduced by 0.020 in. at brazing temperature. To keep the theoretical elongation down to 50%, the parts at room temperature should have a diametral clearance of 0.060 in. (radial clearance of 0.030 in.). The required room temperature diametral clearance for a 50% elongation can also be found by multiplying the calculated ΔC_D value by 3; or (3)(0.020) = 0.060 in.

NOMOGRAPH SIMPLIFIES CALCULATIONS

Nomograph is developed from Eq (5) and eliminates the need for calculating the change in diametral clearance, ΔC_D, for many of the usual combinations of part sizes, metals, and brazing conditions. It assumes that the male member has the higher expansion coefficient—α_r is greater than α_s; hence, the values on the $\alpha_s - \alpha_r$ and ΔC_D scales are negative. Where α_s is greater than α_r, the result on the ΔC_D scale becomes positive, signifying that the joint gap contracts during cooling, thus compressing rather than stretching the filler metal.

Example. A 2½ in. dia cartridge brass tube is to be brazed into a carbon steel plate using a BAg-6 filler metal. Find the room temperature clearance for the first trial braze.

α_s (carbon steel) = 8.61×10^{-6} in./in./F
α_1 (cartridge brass) = 11.60×10^{-6} in./in./F
Solidus temperature for BAg-6 = 1250 F

These are mean coefficient values from 75 to 1200 F. The net temperature change in the brazing cycle is

$$\Delta T = 1250 - 70 = 1180 \text{ F}$$

The difference in expansion coefficients is

$$\alpha_2 - \alpha_1 = (8.61 - 11.60)10^{-6} = -2.99 \times 10^{-6}$$

On the nomograph connect the 2½ in. dia value on the D scale and the 1180 F value on the T scale with index line 1. From the intersection point of the index line with the q-line, extend index line 2 to -2.99×10^{-6} on the $\alpha_s - \alpha_r$ scale. Where index line 2 intersects the ΔC_D scale read the resulting change in diametral clearance.

The result indicates a shrinkage of 0.009 in. when the parts are heated from 70 to 1250 F. By multiplying ΔC_D by 3 to give a 50% theoretical elongation in the filler metal on cooling, the desirable initial diametral clearance is 0.027 in., or 0.0135 in. radial clearance. This represents a good starting point for the first trial braze.

In cases where the nomograph cannot be read with sufficient accuracy, or one of the variables is off the scale, the value ΔC_D can be calculated by substituting the appropriate values in Eq (5) on which the nomograph is based, i.e., $\Delta C_D = D\Delta T\alpha_s - \alpha_r$).

REFERENCE:

Predicting Gap Change Reduces Trial Runs in Brazing Dissimilar Metal Joints, by D. C. Herrschaft, Assistant Manager, Brazing Products Division, Handy & Harman, New York, NY. Published in the Welding Journal, March 1959, p 232-235.

From: SPI paper

Fastening of Glass Reinforced Plastics

Many reinforced plastic applications require mechanical joints or connections as opposed to adhesive bonding. By properly analyzing the nature of the applied loads, serviceable joints are possible with a variety of commercially available fasteners.

MARSHALL D. WEISS Project Engineer
Owens-Corning Fiberglas Corporation

Although many of the assembly problems have been solved with adhesive bonding techniques, there are many instances where only mechanical attachments are capable of meeting design requirements. Such instances include access doors, covers, parts requiring replacement or removal for repair, joints subjected to complex loadings, and joining materials of dissimilar thermal expansions.

While rivets, screws and bolts may all be used, it is often necessary to use modifications of conventional joint designs to achieve the desired results. This is because the lack of ductility of glass reinforced plastics is responsible for the concentration of local stresses, which results in unequal load distribution properties. Also, the lower values of shear and bearing strength make it necessary that reinforced plastics be treated with more care than metals, when designing.

PRE-ASSEMBLY DESIGN

Most of the existing mechanical fastening methods require some form of hole in the plastic material. Some considerations in machining, drilling, punching and tapping are covered from a design standpoint.

Machining. Abrasive quality of the glass in glass reinforced plastics makes it more difficult to machine than other reinforced plastics. All reinforced plastics have certain fundamental properties not common to metals such as; lower shear strength, which permits high cutting speeds and feeds, and greater resiliency, which requires

TABLE I—Holding Forces of Machine Screw Fasteners in Glass Reinforced Polyester—181 Cloth[1]

Fastener Size Thds.	Axial Holding Force				Lateral Holding Force			
	Minimum		Maximum		Minimum		Maximum	
	DoP 16th in.	Force lb	DoP 16th in.	Force lb	DoP 16th in.	Force lb	DoP 16th in.	Force lb
4-40	2	130	5	500	1	210	2	350
6-32	2	170	6	820	1	250	3	700
8-32	3	320	7	1140	2	440	3	810
10-32	3	420	8	1500	2	850	4	1200
1/4-20	4	700	10	2800	3	1200	5	1900
5/16-18	4	820	12	4200	3	2100	6	2800
3/8-16	5	1160	14	6000	4	3300	7	3900
7/16-14	5	1300	16	8000	4	3800	8	5200
1/2-13	6	1660	17	9800	5	5300	10	7500
9/16-12	6	1820	18	12,000	5	5800	11	9000
5/8-11	7	2200	20	15,300	6	7300	13	11,900
3/4-10	7	2550	22	20,600	7	8900	15	15,000

(1) Plastic Mechanical Properties
Tensile Strength ..... 35,000 to 45,000 psi
Edge Compressive Strength..... 25,000 to 37,000 psi
Shear Strength (Johnson)..... 12,000 to 17,000 psi

TABLE II—Holding Forces of Machine Screw Fasteners in Glass Reinforced Polyester—1000 Cloth[1]

Fastener Size Thds.	Axial Holding Force				Lateral Holding Force			
	Minimum		Maximum		Minimum		Maximum	
	DoP 16th in.	Force lb	DoP 16th in.	Force lb	DoP 16th in.	Force lb	DoP 16th in.	Force lb
4-40	1	90	3	500	1	180	2	350
6-32	1	110	4	700	1	220	2	450
8-32	2	230	5	1000	1	280	3	880
10-32	2	260	6	1500	2	750	3	1100
1/4-20	2	320	8	2700	2	1000	4	1800
5/16-18	3	520	10	4000	2	1350	6	2000
3/8-16	3	620	11	4850	3	2600	7	3300
7/16-14	4	950	13	6800	3	3000	9	4500
1/2-13	4	1100	15	7720	4	4500	10	6000
91/6-12	5	1600	16	9000	5	6000	12	9000
5/8-11	5	1750	18	11,600	5	6500	13	10,000
3/4-10	6	2500	22	24,000	6	8000	16	15,000

(1) Plastic Mechanical Properties
Tensile Strength ..... 30,000 to 45,000 psi
Edge Compressive Strength..... 18,000 to 27,000 psi
Shear Strength (Johnson)..... 14,000 to 17,000 psi

TABLE III–Holding Forces of Machine Screw Fasteners in Glass Reinforced Polyester–1½ oz Mat[a]

Fastener Size Thds.	Axial Holding Force				Lateral Holding Force			
	Minimum		Maximum		Minimum		Maximum	
	DoP 16th in.	Force lb	DoP 16th in.	Force lb	DoP 16th in.	Force lb	DoP 16th in.	Force lb
4–40	2	40	5	450	1	150	2	290
6–32	2	60	6	600	1	180	2	380
8–32	2	100	7	1150	1	220	3	750
10–32	2	150	8	1500	2	560	4	1350
1/4–20	3	300	10	2300	3	1300	5	1900
5/16–18	3	400	12	3600	3	1600	7	2900
3/8–16	4	530	14	5000	4	2600	10	4000
7/16–14	4	580	16	6500	5	3800	12	5000
1/2–13	4	620	18	8300	6	5500	14	6000
9/16–12	4	650	20	10,000	7	6500	15	8000
5/8–11	4	680	22	12,000	7	6800	16	11,000
3/4–10	4	700	24	13,500	7	7000	17	17,000

(1) Plastic Mechanical Properties
Tensile Strength ..... 6,000 to 25,000 psi
Edge Compressive Strength..... 10,000 to 22,000 psi
Shear Strength (Johnson)..... 10,000 to 13,000 psi

greater clearance and less rake on cutting tools. Machining parallel to the laminations should be avoided and in all operations, tools should be kept sharp to avoid splitting of the laminations and similar damage.

Drilling. Drill speeds of 65-80 surface feet per minute, and a feed of 0.016 in. per revolution for a ¼ in. drill is possible. Lower shear strength of the plastic requires less power than for metals, and a smooth hole free from chipping is possible.

Punching. About ½ the press capacity is required for punching holes in plastic than for steel. However, because of the shrinkage of plastic the punch diameter should be 4-5% greater than the plastic thickness; a stripping plate of high spring loading is necessary to clear the lifted laminate from the punch face; and die clearance should be ½ those specified for steel. Also, minimum hole diameter should be 75% of laminate thickness and sharp edges are possible in laminates up to 3/16 in. thick, fair edges up to 5/16 in., and rough but clean edges in thickness up to ½ in.

Tapping. The maximum accuracy obtainable in glass reinforced parts is a class 2 fit with a 75% thread. For most applications this is adequate; where a more precise fit is required, inserts can be used. Tables I, II, and III give the pull-out strength and lateral holding force for standard machine screws in tapped holes.

BOLTED CONNECTIONS

Fastener selection is usually governed by the loads imposed on the assembly and the stresses set up in the fastener. This is especially true in heavily loaded structures.

Required fastener tension can usually be calculated, but it is much more difficult to know the tension in the fastener during assembly. Excessive torque at installation, especially when using small bolts, can cause surface damage under the head or nut; even though the axial load on the fastener, developed from the torque, is only 10% of the total. Remaining portion of the load is taken up in friction between the bolt and nut threads.

Loads and stresses per unit torque, Table IV, are calculated based on a coefficient of friction of 0.12 between the bolt and nut threads, and a coefficient of 0.14 between nut and washer. Values apply to cap screws, machine screws, bolts, and studs tightened with a wrench; they do not apply to screw driver fastened members. In specifying a fastener for a particular joint design, the external load and the assembly load must be considered, and washers or bolting strips added against the plastic surfaces.

Bolt size. A minimum ratio of fastener diameter to laminate thickness, d/t of 1, will allow the plastic to develop its full bearing strength. At d/t ratios of ¼, ⅛ in. laminate and ⅛ in. dia bolt, it is possible to shear the fastener before plastic failure occurs.

Hole size. Holes should be drilled or reamed 1/64 in. larger than the bolt diameter. Misalignment will cause high stresses when the fastener is inserted, and the connection may not prove serviceable.

Spacing. At small edge distances, joint failure is usually through shear out at the ends, or tension failure at the net section. Load carrying capacity of the net section is, therefore, less than its area and tensile strength of the plastic would indicate. Effects of notch sensitivity are important and are about 3½ times the average stress in the part.

Mat laminates, because of the random arrangement of the fibers, are susceptible to stress concentration at a hole in all directions of loading. Fabric laminates show less notch sensitivity at holes when the load is in the direction of wrap. Mat laminates require the greatest edge distance; edge distance ratio of 4.5D and side distance ratio of 3.5D appears adequate for all directions of loading.

RIVETED CONNECTIONS

Joints should be designed so that rivets are not in tension since a slight eccentricity of the load will exert a prying action of the rivet load. Action is especially marked under repeated loading. If tensile loading is unavoidable, the safe tension valve of a rivet is taken as ½ the safe single shear value given in Table V.

Rivet selection. Similar to the bolted connections, the diameter to thickness ratio, d/t, should be 1 or greater. Safe single shear value for the selected rivet size can be used to find the number of rivets required. However, to this value should be applied a safety factor of 3 to 4 based on the bearing strength of the plastic being applied.

Rivet holes. Size should be large enough to permit easy and rapid as-

TABLE IV–Loads and Stresses Per Unit Torque for Fractional Size Threads

Size, in.	No. of threads per in. Coarse	Fine	Extra fine	Basic area of section at root of threads, sq in.	Max combined tensile stress, psi, in screw with torque of 1 in.-lb on nut	Max axial load, lb. on screw with torque of 1 in.-lb on nut
1/4	20			0.0269	1115	20.6
		28		0.0326	879	21.5
			32	0.0352	807	21.7
5/16	18			0.0454	512	16.6
		24		0.0524	432	17.1
			32	0.0590	377	17.6
3/8	16			0.0678	292	14.3
		24		0.0809	261	14.9
			32	0.0890	231	15.3
7/16	14			0.0933	179	12.2
		20		0.1090	150	12.6
			28	0.1217	132	13.0
1/2	13			0.1257	118	10.9
		20		0.1486	97.1	11.4
			28	0.1634	86.3	11.7
9/16	12			0.1620	82.3	9.9
		18		0.1888	68.8	10.3
			24	0.2054	63.3	10.5
5/8	11			0.2018	59.3	8.72
		18		0.2400	48.2	9.24
			24	0.2586	44.3	9.33
3/4	10			0.3020	32.1	7.34
		16		0.3513	27.0	7.64
			20	0.3725	25.3	7.68
7/8	9			0.4193	20.4	6.52
		14		0.4805	17.6	6.78
			20	0.6921	10.6	6.92
1	8			0.5510	13.6	5.73
		14		0.6464	11.6	5.99
			20	0.6921	10.6	6.09
1 1/8	7			0.6931	9.61	5.08
		12		0.8118	8.06	5.32
			18	0.8772	7.43	5.43
1 1/4	7			0.8898	6.71	4.62
		12		1.0238	5.73	4.80
			18	1.0969	5.35	4.90
1 3/8	6			1.0541	5.17	4.18
		12		1.2602	4.24	4.40
1 1/2	6			1.2938	3.84	3.86
		12		1.5212	3.31	4.16
			18	1.6101	3.17	4.32

sembly but not so large as to permit excessive bulging or buckling. A hole about $\frac{1}{64}$ in. larger is adequate.

Rivet spacing. Spacing requires that there is sufficient material between the hole and the edge of the laminate as well as between centers of holes in a row. This is necessary to allow the plastic to develop its full bearing strength. Using a stress concentration factor of 3.0, the recommended edge distance is 4.5D; side distance is 3.5D.

SCREW CONNECTIONS

By applying suitable safety factors to allowable holding strengths, many

TABLE V–Load, Lb, Required to Produce Failure of One Rivet in Single Shear

Size of Rivet, in.	Cold Driven					
	2S	A17S-T3	17S-T3	17ST31(1)	24S-T4	61S-T6
1/8	143	428	505	441	544	389
5/32	218	655	775	675	834	596
3/16	315	945	1120	974	1200	860
1/4	571	1710	2020	1760	2180	1560
5/16	901	2700	3200	2790	3440	2460
3/8	1290	3860	4590	3980	4925	3510
7/16	1770	5320	6340	5480	6800	4840
1/2	2300	6900	8180	7110	8780	6270
9/16	2660	8920	10,560	8920	11,380	7870
5/8	3550	10,700	12,680	11,000	13,600	9680
3/4	5070	15,200	18,000	15,700	19,370	13,800
7/8	....	.....	.....	.....	.....	18,700
1	....	.....	.....	.....	.....	24,300

[1] Driven immediately after quenching.

TABLE VI—Pull-Out Strength of Type F—¼-20 Thread Cutting Screws

Effect of Varying Pilot Hole Size

Pilot hole size		Pull-out Strength, lb		
No.	in.	1000 Cloth 56% Glass	Mat 37% Glass	Mat 15% Glass
3	0.2130	3110	2690	1640
2	0.2210	2870	2600	1750
1	0.2280	2800	2670	1850
15/64	0.2343	2080	2400	1670
C	0.2420	1430	1870	1370

TABLE VII—Pull-Out Strength of Type Z—¼-14 Thread Forming Screws

Effect of Varying Pilot Hole Size

Pilot hole size		Pull-out Strength, lb		
No.	in.	1000 Cloth 56% Glass	Mat 37% Glass	Mat 15% Glass
3	0.2130	2830	1510	1150
2	0.2210	2690	1620	1510
1	0.2280	2290	1190	1400
15/64	0.2343	1815	1040	1130
C	0.2420	580	500	380

Note: Depth of penetration, 3/4 in.

TABLE VIII—Pull-Out Strength of Type F Thread Cutting Screws

1 1/2 oz Mat Laminate—37% Glass

Size	Initial Penetration 16 ths in.	Pull-out Strength, lb at initial Penetration	Pull-out Strength, lb Per 1/16 in.	Range 16 ths in.
4-40	2	10	150	2-6
6-32	4	130	90	4-12
8-32	4	360	230	4-12
1/4-20	5	400	300	5-17

1000 Cloth Laminate—56.6% Glass

Size	Initial Penetration 16 ths in.	Pull-out Strength, at in. Pen., lb	Pull-out Strength, per 1/16 in., lb	Range 16 ths in.	Approx. Break Load of Fastener, lb
4-40	2	70	130	2-6	650
6-32	4	250	185	4-9	1300
8-32	4	400	195	4-12	2200
1/4-20	5	350	365	5-12	4000

TABLE IX—Pull-Out Strength of Type Z Thread Forming Screws

1000 Cloth Laminate—56.5% Glass

Size	Initial Penetration 16 ths in.	Pull-out Strength at In. Pen., lb	Pull-out Strength per 1/16 in., lb	Range 16 ths in.	Approx. Break Load of Fastener lb
4-24	2	70	150	2-6	650
6-20	4	200	165	4-9	1100
8-18	4	120	170	4-15	2000
14-14	5	300	300	5-18	4300
3/8-12	4	100	410	2-16	....

1 1/2 Oz Mat Laminate—37% Glass

Size	Initial Penetration 16 ths in.	Pull-out Strength at In. Pen., lb	Pull-out Strength per 1/16 in., lb	Range 16 ths in.
4-24	2	110	115	4-6
6-20	4	110	85	4-10
8-18	4	180	145	4-14
14-14	5	100	265	5-20
3/8-12	4	200	250	4-8

of the standard and patented screw designs are satisfactory, Table VI and VII, for many applications.

Hole size. Data indicates that for a given type fastener and laminate, pull-out strength varies directly with fastener diameter. For cloth laminates of 56% glass content and mat laminates of 37% glass content, pull-out strengths are lower with the larger pilot hole sizes. For the lower glass content mat laminates, there is an optimum pilot hole size for maximum pull-out strength. If the holes are too large or too small, the pull-out strength is affected adversely. Lower strength for small pilot holes is probably caused by stresses induced in the plastic in driving the fastener.

An example of using the type of data in Table VIII, and IX, assume the attachment of a member to a molded reinforced part with a bonded mat of about 37% which is ⅜ in. thick. The estimate of the tensile load on the fastener is 400 lb and a No. 8-32 Type F hardened steel self-tapping screw, in through holes will be used. Assuming a maximum penetration depth of ⅜ in. from Table VIII, this fastener will support; 360 lb for the first 4/16 in., 230 lb for the next ⅜ in., for a 590 lb total. If the factor of safety of four is used, each fastener will support 147 lb, and, therefore, 3 screws will be required.

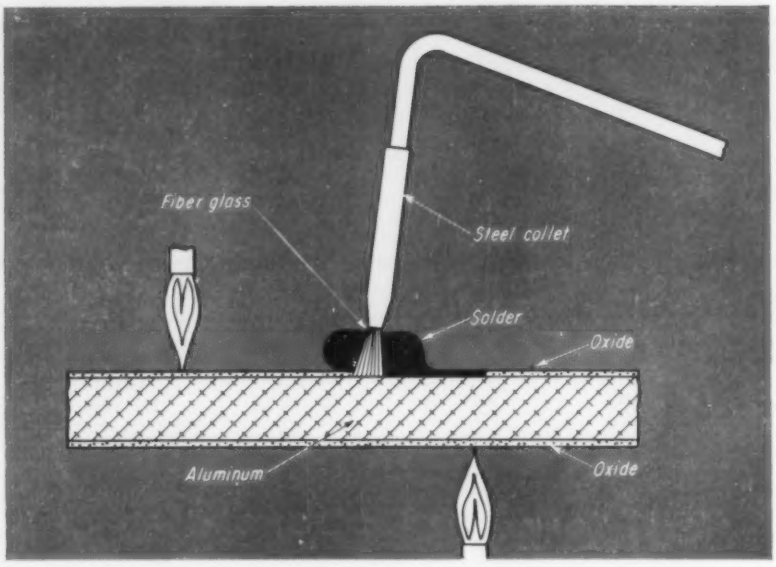
CONCLUSIONS

Mechanical fasteners, properly selected and applied, can be used to make plastic-to-plastic and plastic-to-metal connections. Standard fasteners are suitable, but conventional joint designs may need modifications. These are necessary as the mat-has lower shear and bearing strengths than most metals. Measures to prevent damage to the plastic surface when under load as well as during installation of the part are necessary.

REFERENCE:

Mechanical Fasteners for Glass Reinforced Plastics by Marshall D. Weiss, Project Engineer, Reinforced Plastics Eng. Service Dept., Owens-Corning Fiberglas Corporation, Ashton, Rhode Island. Presented at the 14th Annual Meeting of the Reinforced Plastics Division, SPI, Chicago, Illinois, Feb. 1959.

From: Reynolds booklet



Glass fiber brush . . . is the newest and considered the best method of soldering aluminum. The brush is used to abrade the oxide film so that the solder can fuse to the bare aluminum.

Methods of SOLDERING ALUMINUM

Reaction-flux soldering, friction soldering, and ultrasonic soldering are more applicable to aluminum than to other metals. Given are methods of soldering and properties of solders for aluminum.

CHARLES BRUNO
Chief Welding Engineer
Reynolds Metals Company

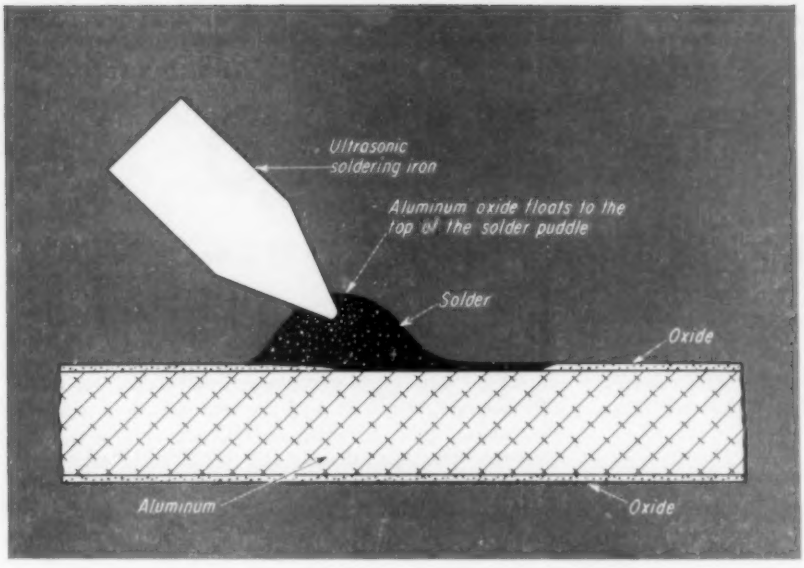
Soldering is a means of joining metals by bonding them together with a metal alloy that has a lower melting point than the metal joined. Although soldering, brazing and welding are similar in many respects, soldering and brazing are performed at temperatures lower than the melting point of the alloys being joined while welding temperatures are higher than the melting points of the parts being joined. Soldering differs from brazing in that a much lower temperature is used. Table I compares the three methods of joining aluminum.

The mechanical means of soldering aluminum uses abrasion or ultrasonic cavitation to remove the oxide layer that forms on aluminum and makes wetting or tinning of the surface impossible. In abrasion type soldering after a molten pool of solder is placed on the surface of the part, the surface under the pool is scratched. This abrasion removes the oxide film and allows the solder to tin the bare aluminum surface. In ultrasonic soldering, cavitation produced in the molten solder pool between the tip of the ultrasonic iron and the aluminum surface being soldered breaks up the oxide by erosion.

The chemical process uses any of a number of suitable fluxes that dissolve the surface oxide film and then remain on the surface to shield the bare aluminum from the atmosphere. Heat applied to the base metal melts the solder, immersed in the flux puddle, to form a bond. The melting temperature of the solder to be used determines the selection of the flux as the reaction temperature of the flux must be the same or slightly higher than the melting point of the solder.

A difference between soldering aluminum and other common metals is that the solder does not flow into certain types of joints on aluminum as readily as on other metals. This reduced flow is particularly noticeable in joints with extremely close clearances. Where solder will flow into joints with a 0.001 in. clearance on some metals, aluminum requires a 0.030-0.035 in. clearance for adequate flow.

Also, resistance to corrosion of soldered aluminum joints is far more dependent upon the composition of the solder than it is for similar joints of copper, brass or steel. Joint design and the environment of exposure also



Ultrasonic iron . . . bombards the aluminum surface with ultrasonic vibrations and removes oxide which floats on surface of the solder puddle. The aluminum surface then bonds with the overlying molten solder.

affect the corrosion resistance of the joint. Waterproof lacquer or paint will preclude moisture penetration.

METHODS OF SOLDERING ALUMINUM

Aluminum can be soldered by most of the common methods such as iron, torch, hot plate, dip, and furnace soldering. But it can also be soldered by several methods which are more applicable to aluminum than to the other common metals. These include reaction-flux soldering, friction soldering, and ultrasonic soldering. Usually, the soldering method will depend primarily upon the size and shape of the part, the joint design and number, performance requirements of the assembly and the economics of the various methods.

Two types of solders are commonly used; the reaction type which requires a flux, and the friction type which does not require a flux but an abrasive action for tinning. A major advantage offered by the friction type solders is that they eliminate the possibility of corrosion that exists when fluxes are not completely removed from soldered joints. Table II shows the solders that can be used for joining aluminum to aluminum or to other metals by the methods shown.

Soldering iron. When using an iron more heat is required for aluminum and copper than for other metals because of the higher thermal conductivity. High heat output is essential for all materials being soldered.

Soldering flame. Probably the most popular method of soldering aluminum on a nonproduction-line basis. It gives adequate heat to the workpiece more quickly and conveniently than other methods. The high heat output is especially valuable as the high thermal conductivity of aluminum results in rapid conduction of heat from the joint area. Also, aluminum solders have higher melting points than other soft solders and the hot flame promotes rapid melting of the solder into the joint.

Hot plate soldering. For small flat aluminum parts, a gas or electric hot plate can be used. Parts are assembled and laid on the plate and brought to soldering temperature. This method is usually restricted to parts which lie flat; however, other shapes can be soldered. Auxiliary gas burners are needed and the parts should be clamped.

Dip soldering. A crucible is filled with a molten reaction type solder and the temperature held at about 100-200 F

TABLE I–Characteristics of Joining Methods for Aluminum

Method	Temperature	Filler Material
Soldering	Considerably below melting point of metal being joined (300–700 F). Base metal does not melt and filler metal is required.	Tin or Zinc Base Alloy
Brazing	Slightly below melting point of metal being joined (1050–1200 F). Base metal does not melt and filler metal is required.	Aluminum-Silicon Alloy
Welding	Exceeds melting point of metal being joined (above 1250 F). Base metal melts and filler metal may or may not be required.	Various aluminum alloys. Fillet may be formed by melting edges of metal being joined.

Table II–Methods of Soldering Aluminum

Soldering Method	Aluminum Solders: Reaction Type	Aluminum Solders: Friction Type
Soldering Iron	X	X
Soldering Flame	X	X
Hot Plate	X	X
Dip Soldering	X	—
Furnace Soldering	X	—
Ultrasonic Soldering	—	X
Dip bath with special abrading mechanism	—	X

TABLE III—General Characteristics of Aluminum Solders

Type	Melting Range F	Common Constituents	Ease of Application	Wetting of Alum.	Relative Strength	Rel. Corrosion Resistance	Effect on Parent Metal
Low Melting Point	300–500	Cadmium Tin Bismuth Lead Zinc	Best	Poor to Fair	Low	Low	Negligible
Inter. Melting Point	500–700	Cadmium Tin Zinc	Moderate	Good to Excellent	Moderate	Moderate	Moderate
High Melting Point	700–800	Zinc Tin Aluminum Copper	Most Difficult	Good to Excellent	High	Good	Reduces Strength at Joint

above the melting point of the solder. The method is used for joining lugs, clips, or clamps on wire ends. Usually the pot is large enough to permit several parts to be soldered at the same time.

Furnace soldering. Method is used for the simultaneous or continuous soldering of large quantities of parts. Parts are jigged with the solder position, either as a preplaced filler alloy or as a coating on the components, and then fluxed. A conveyor carries the parts through the furnace which has three heat zones for preheating, soldering, and slow cooling.

Friction soldering. Aluminum surface is abraded which permits direct contact of the molten solder to the bare aluminum. A simple abrasion method makes use of solders composed of zinc, tin, cadmium, silver, and aluminum, alloyed in proper proportions to produce a solder rod that will melt below the melting point of aluminum, yet melt so slowly that the rod is used to abrade the aluminum surface. Solders generally used have melting points of about 450 to 750 F. Typical abrasion solders for aluminum have a tin-zinc composition range of 75-85% tin, 15-25% zinc. Zinc-cadmium solders are also used.

Glass fiber brush soldering. This is the latest variation of the friction method, and is also the newest and potentially the best method of soldering aluminum. Used is a glass fiber brush to remove the oxide coating by abrading it down through a layer of molten solder. Excellent results achieved are due to the characteristics of the glass fibers. First, they do not conduct heat easily, thus the overlying layer of molten solder does not solidify prematurely. Also, the brush picks up molten solder and spreads it evenly over the surface. This action facilitates deposition or the bonding of the solder as the aluminum surface is abraded.

Ultrasonic soldering. Oxide film is removed from the surface by a high frequency vibration. When the ultrasonic wave is submerged in molten solder, cavitation effects remove oxides from aluminum objects immersed in the solder. Ultrasonic equipment can be used to solder aluminum, copper, brass, silver, magnesium, germanium, and silicon. Sound soldered joints can be obtained on all types of aluminum sheet, castings, and other mill products at high speed and relatively low cost.

Grinding wheel soldering. The surface of a grinding wheel is loaded with a soft solder such as 60-40 lead-tin solder. By abrading the surface of the material to be soldered, borosilicate glass, titanium, molybdenum, tantalum, stainless steel, tungsten, ceramics and cobalt can be successfully tinned. After tinning, these materials can be soldered by conventional means to themselves or to aluminum, brass, and copper.

PROPERTIES OF SOLDERS FOR ALUMINUM

Many different types of solders have been developed for joining aluminum. The most convenient classification system divides all aluminum solders into those with low, intermediate, and high melting points. Table III shows this classification.

Low temperature solders are generally tin-zinc alloys in which tin is present in the larger amount. Best is probably one containing 91% tin and 9% zinc. This solder melts at about 400 F, wets aluminum readily, flows easily, and has a higher resistance to corrosion on aluminum than any of the low-temperature solders. In general, assemblies joined with low temperature solders have poor resistance to corrosion and should not be used in corrosive environments unless some protection is applied to the soldered joints.

Intermediate temperature solders are usually either zinc-cadmium or zinc-tin alloys containing 30 to 90% zinc. Other metals may be present in trace amounts such as lead, bismuth, silver, nickel, copper, and aluminum. Among the more common are the 70-tin 30-zinc, 70-zinc 30-tin, and 60-zinc 40-cadmium solders. As a result of their higher zinc content, these solders generally wet aluminum more readily, form larger fillets, and produce stronger and more corrosion resistant joints than the low temperature solders.

The high temperature solders contain from 90 to 100% zinc together with small amounts of high melting alloys such as silver, aluminum, copper, and nickel. These additions serve to lower the soldering temperature and to obtain a wider melting range. These are the strongest and cheapest of all solders for aluminum. Also, they have the best corrosion resistance characteristics.

REFERENCE:

Soldering Aluminum by Charles Bruno, Chief Welding Engineer, Reynolds Metals Company, Richmond 18, Virginia. Published by Reynolds Metals Company, 1959, 22 p.

From: SAE Journal

6 basic design suggestions for Brazed Honeycomb Sandwich

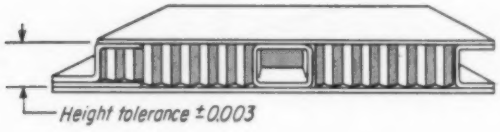
Designs to achieve practical, producible, economical structures of brazed honeycomb sandwich panels are illustrated.

FLOYD F. RECHLIN
Solar Aircraft Co.

1. Minimize detail design subject to tight tolerance needs of brazing process.

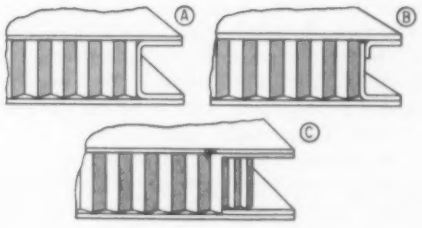
Intimate contact must be maintained between all members being bonded. To achieve this contact height tolerances of ±0.003 in. must be held on integral parts of the assembly. Producibility and cost are affected.

In the design below, heights of edge members, spar and core blanket are all subjected to the same ±0.003 in. tolerance. Also, core must be step machined and its



tolerance held. A practical design approach is to concentrate on the core blanket. Core blanket can be surfaced to an accurate dimension easily with electromechanical methods of machining. Formed members with fixed heights are eliminated as shown by designs (B) and (C), right.

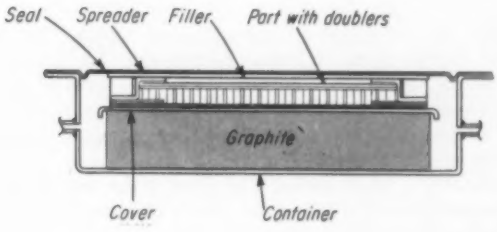
If a small weight penalty is acceptable, the channel can be redesigned as two adjustable angles, (B). After positioning, angles can be tack-welded to the core and the unit brazed to form a solid component. A further improvement (C), on edge member design is to eliminate the vertical legs and substitute a dense core to transmit panel loading.



Design objective is to reduce the sandwich to its most perfect form—a simple sandwich made up of core and facings with no other full depth members—for producibility. Proper attention to part design within required tolerances will help to insure producibility.

2. Make allowances for uniform brazing pressure and temperature distribution.

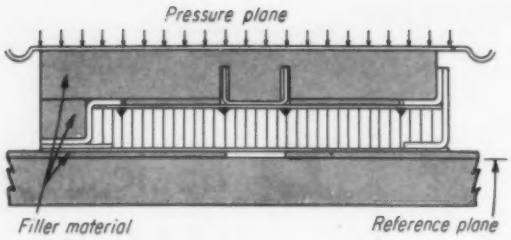
The need for uniform pressure planes and heat distribution is a requirement of the brazing process which could influence design. The ideal brazing configuration consists of a completely flat honeycomb sandwich having no external steps or protuberances. Even minor deviations from this uniformity of surface must be compensated for by filler sheets or filler material to provide even pressure planes on both sides of the sandwich. A small amount of filler can be tolerated. However, if the design configuration extends too far from the normal plane of the sandwich, the mass of the compensating filler material tends to become a heat sink, causing undesirable temperature gradients around the



sandwich at brazing temperatures, which increases the possibility of producing a partially brazed part.

Hypothetical design has extended edge members, an external channel along the center of the panel, and a doubler located on the opposite face. Filler material must be added, as shown, to maintain uniform pressure brazing planes. This does not guarantee perfectly distributed pressures on the face of the sandwich. Filler must have allowances made in its shape for differing thermal expansion between itself and the sandwich material at brazing temperatures. Thus, areas would occur, as shown by the dark triangles, where no brazing pressure would be experienced.

External stiffening members can not always be avoided, but the design should minimize these projections away from the face. Members could be attached after brazing.



For example, attachment of two angle sections to a doubler by indirect resistance, effectively forms the desired channel section. Then, the only filler material needed would be about the external doubler.

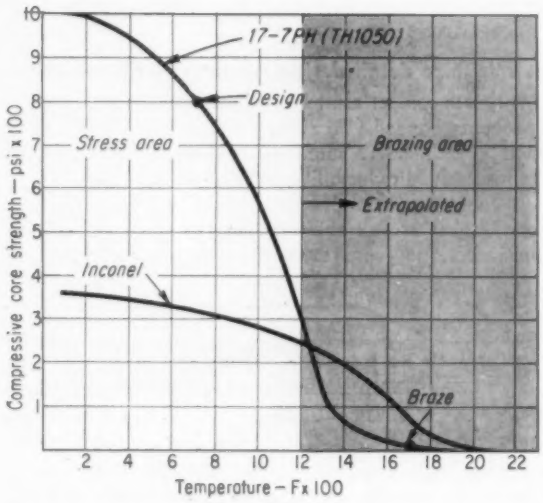
3. Consider brazing temperatures and pressures in the choice of structural material.

Item is peculiar to light-weight brazed structures. Normal structural design is concerned only with the applied loads during lengths of exposure at service temperature. But brazing temperatures and pressures influence honeycomb design too. Changes could occur in the external and internal structural composition and is reflected mostly in the selection of core density.

Most designs are concerned with only the physical property values, to the left of the shaded area: a honeycomb sandwich component must meet the physical property standards of the shaded area. Core size and density adequate to withstand service loads might be incapable of meeting the pressure requirements at brazing temperature. When heavy gage faces, incorporated doublers, and edge members must be brazed together greater pressures are required than the pressure needed to hold the facings flat to the core blanket. These heavy pressures must be withstood by the core because of uniform pressure distribution.

Design recourse is to consult materials and processes group or brazing facility to determine if the selected core density can meet the brazing temperature and pressure requirements. A general rule is to avoid extremely thin foil thickness, 0.001 in. and less, unless all parts are thin.

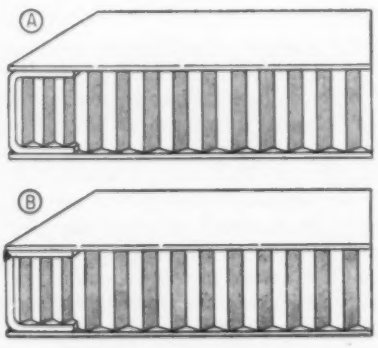
Brazing alloy can also govern core density. If high-temperature materials and brazing alloys are being considered, the metallurgical effect of braze alloy on the core foil during brazing should be investigated.



4. Insure that the design can be assembled for brazing.

Since honeycomb sandwich is made up of individual components which must be carefully laid up before brazing, part of the design is to make provisions to guarantee shear ties structural adequacy by tack-welding the core and vertical faces of included members. Mechanical or welding attachment methods are used between laying surfaces not in the plane normal to the faces (right).

In the design a closeout member is required at the edge of the honeycomb panel for smoothness. Channel section is a good choice, but there is no way to get a proper shear tie between the core and inner face of the section. If, however, the core is spot tacked to a closeout

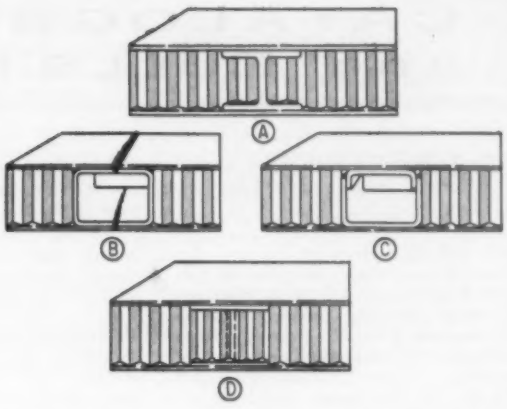


angle after which a doubler is welded to the angle to form the channel section prior to brazing, a shear tie is made.

If smoothness is unnecessary, two doublers separated by dense core acting as a replacement for the channel section web would form the closeout (right).

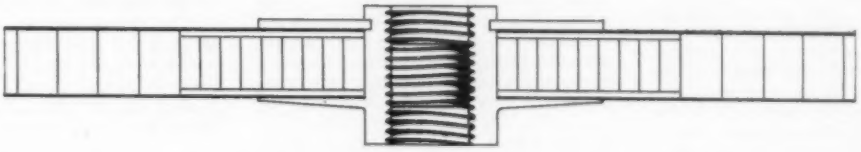
In this design a structural spar is needed through the center of the honeycomb sandwich. Normal design practice is a I-beam. However, a guaranteed shear tie between core and the web of the beam can not be made. A box spar is an answer. It is formed by fusion-welding two channels together after the core is spot-tacked to the channel sections. A better producible design permits single facings, but provisions to insert a backup electrode to tack-weld the two pieces making up the box spar is necessary.

Another method, which does not impose the weight penalty of the box spar, is to substitute a dense core in place of the I-beam web. Spar caps are simple doublers with height tolerances entirely concentrated in the machining of the core between them. Tolerances are easily held in this type of construction.



The I-beam, (A), does not guarantee a shear tie, while the box spar, (B) and (C), does. The dense core, (D), does not impose the weight penalty of other designs.

5. Incorporating varying core densities to transmit loads internally.



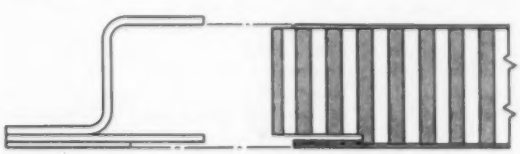
Varying density core offers unlimited design opportunities. Not only can densities be varied by inserting areas of smaller cell or heavier gage core, but sections of the normal core blanket can be shaped or crushed readily during the layup stage to form load carrying paths.

When design calls for fasteners in the sandwich, insertion of a small area of denser core in the parent core blanket offers greater local compressive and bearing strength. Doublers may be included on either side of the core blanket to aid in load transmittal. The fastener can be either brazed or mechanically locked in position, depending on the degree of shear that must be transmitted.

6. Attempt to treat honeycomb sandwich as a material.

It is expected that flat honeycomb sandwich panels will become stock items. It will be possible to rough cut the panels to size, form them to the desired shape or curvature, finish machine and attach the needed edge members by brazing, welding, or mechanical joining. By using variations of these techniques the designer can standardize on basic panels and reduce cost.

Secondary attachment of edge members to simple panels is an accomplished fact. Mechanical attachment, using doublers and dense core, is an established method. Secondary brazing for attaching edge members is being investigated. The intent is to accomplish this brazing by using a C-shaped furnace constructed to travel along the edges of the panels.



Cross section of a typical secondarily brazed edge member and how various members are added is shown. Doubler is secondarily brazed in place. Doublers can be located within 0.050 in. of the 0.010 faces without reducing load transfer strength. This eliminates the risk of cutting into the parent metal of the facing when machining a slot for secondary insertion of the doubler. Cell walls remaining after cut and the deposited braze metal aid in maintaining load transfer characteristics.

REFERENCE:
Brazed Honeycomb Sandwich by Floyd F. Rechlin, Solar Aircraft Co. Published in the SAE Journal, October, 1958, p 56-63.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(G-1) **Adhesives**—Brochure, 16 pp. Describes adhesives and production methods used in manufacture of curtain wall and other panel assemblies consisting of variety of cores and faces. Contains test data and details of mass production bonding techniques. Rubber & Asbestos Corp, 225 Belleville Ave, Bloomfield, NJ.

(G-2) **Hammer-driven Rivets**—Catalog, 6 pp. Shows engineering drawings and full specifications on the complete line of pin grips for metal-to-metal and metal-to-wood fastenings. Star Expansion Industries Corp, Mountainville, NY.

(G-3) **Silver-brazing Alloys**—Bulletin, 24 pp. Advantages and economics of joining similar and dissimilar metals with silver brazing alloys. Handy & Harman, 82 Fulton St, NY 38, NY.

(G-4) **Large-forged Fasteners**—Catalog, 38 pp. Contains engineering and ordering information of large nuts, bolts, eye bars and special forged fasteners for heavy construction industry, ship building, machine tool industry and power plant installations. Joseph Dyson & Sons, Inc, 5125 St Clair Ave, Cleveland 3, Ohio.

(G-5) **Torque Wrenches**—Bulletin, 28 pp. Formulas, applications, engineering data, screw torque data, adapter problems and general principles. P A Sturtevant Co, Addison, Ill.

(G-6) **Thread-cutting Screws**—Catalog, 32 pp. Gives strength and tightening torques, specifications, selection charts and operational drawings. Shakeproof Div of Illinois Tool Works, St Charles Rd, Elgin, Ill.

(G-7) **Snapslide Fastener**—Catalog, 7 pp. Photos and specifications on three sizes; standard snapslide fastener for quick installation and removal of assembled components. Dimco-Gray Co, 207 E 6th St, Dayton, Ohio.

(G-8) **Rivets**—Catalog, 15 pp. Rivet data and selection suggestions for proper sizes and lengths. Also, condensed machine data. Chicago Rivet & Machine Co, 950 S 25 Ave, Bellwood, Ill.

(G-9) **Rivnuts**—Catalog, 14 pp. Shows applications, types, head styles, materials, grip ranges and how to install. Covers complete line of header tools and parts lists. B F Goodrich Aviation Products, 500 S Main St, Akron, Ohio.

(G-10) **Weld Fasteners**—Brochure, 8 pp. Advantages, typical applications by industry and a chart of available styles of nuts, screws, pads, pins, brackets, knobs, and handles for resistance welding. The Ohio Nut & Bolt Co, 41 First Ave, Berea, Ohio.

(G-11) **Sealant**—Brochure, 6 pp. Describes properties and methods of application. Product locks nuts to bolts, seals piping and tubing joints, retains bearings and sleeves without press fits. Requires no heat or mixing. Includes case histories, grade selector charts, and usage tables. American Sealants Co, 103 Woodbine St, Hartford 6, Conn.

(G-12) **Fasteners**—Catalog, 17 pp. Illustrates recent achievements in forming a variety of rivet, nail and small part shapes by the cold heading process. John Hassall, Inc, Box 2233H, Westbury, LI, NY.

(G-13) **Retaining Rings**—Catalog, 16 pp. Engineering specifications, illustrations and descriptions of external and internal types stacked retaining rings, dispenser bases and application tools. Industrial Retaining Ring Co, 57 Cordier St, Irvington, NJ.

(G-14) **Special Washer**—Brochure, 4 pp. Describes the locking principle, suggested applications and data on installations of nylon locking and sealing washer. Nylogrip Products, 449 Watertown St, Newton, Mass.

(G-15) **Screwstick**—Brochure, 4 pp. Description and sample of miniature screws joined in stick form. Includes application, technical and dimensional information. American Screw Co, W Main St, Willimantic, Conn.

(G-16) **Fasteners**—Bulletin, 8 pp. Descriptions, features, availability of sizes and materials for general line of industrial fasteners. Standard Pressed Steel Co, Jenkintown, Pa.

(G-17) **Quick-forming Adhesive**—Bulletin, 10 pp. Describes properties, type of bonds formed, and directions for use of adhesive that forms high strength bonds without the aid of heat, excessive pressure or catalyst. Eastman Chemical Products, Inc, Chemicals Div, Kingsport, Tenn.

(G-18) **Specialty Nut**—Catalog, 8 pp. Internally threaded tabular rivet which can be automatically fed and set by standard TRS riveting machines. Combines the features of a rivet and a nut. Information on design and size data, head styles, applications and machines for automatic feeding and setting. Tubular Rivet and Stud Co, Weston Ave, Quincy 70, Mass.

(G-19) **Metal Goods**—Catalog, 44 pp. Illustrates eyelets, rivets, snap fasteners, grommets and washers, hole plugs, stampings, terminals, and others. Also shows a complete line of attaching machines, Edwin B Stimpson Co, Inc, 70 Franklin Ave, Brooklyn 5, NY.

(G-20) **Eyelets**—Catalog, 104 pp. Contains illustrations and dimensions of eyelets together with description of line of eyeleting machines. Edwin B. Stimpson Co, Inc, 70 Franklin Ave, Brooklyn 5, NY.

(G-21) **Rivets**—Catalog, 96 pp. Split-tubular-side prong and special rivets together with a line of riveting machines. Edwin B Stimpson Co, Inc, 70 Franklin Ave, Brooklyn 5, NY.

(G-22) **Adhesives**—Catalog, 8 pp. Includes product illustrations and selector chart to aid in choosing right adhesive to suit specific job or production requirements. Pierce & Stevens Chemical Corp, 710 Ohio St, Buffalo, NY.

(G-23) **Preassembled Fastener Units**—Catalog, 36 pp. Includes point, head and thread data in addition to construction materials and finishes of lock washers. Shakeproof Div of Illinois Tool Works, St Charles Rd, Elgin, Ill.

(G-24) **Industrial Fasteners**—Catalog, 163 pp. List prices, container quantities, extras, weights, and other data on standard bolts, spikes, rivets, cap screws, studs, and others. Includes special products such as heat-treated carbon and alloy-steel fasteners. Bethlehem Steel Co, Bethlehem, Pa.

(G-25) **Industrial Adhesives**—Brochure, 4 pp. Various adhesives commonly used by industry. United Industrial Sales Div, United Shoe Machinery Corp, c/o B B Chemical Co, 784 Memorial Dr, Cambridge, Mass.

(G-26) **Fastening Devices**—Catalog, 8 pp. Condensed information pertaining to various sizes of quick-operating fasteners. Camloc Fastener Corp, 22 Spring Valley Road, Paramus, NJ.

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(G-29) **Anti-vibration Fastener**—Brochure, 6 pp. Describes construction and method of using along with line drawings of seven standard sizes currently available. Also includes physical specifications of the basic neoprene compound used and sizes recommended for various panel thicknesses. Rockwell Products Corp, 146 Central Ave, Newark, NJ.

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(G-30) Adhesive Materials—Brochure, 12 pp. Lists and describes line of printed tapes; paper, cloth and plastic films; die-cut pick-off labels; aluminum plates; decals; all with adhesive backing. Topflight Corp, 160 E 9th Ave, York, Pa.

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(G-32) Turned Nuts—Catalog, 20 pp. Describes and illustrates precision brass and aluminum nuts including standards, specials and miniatures. Complete specifications on nut sizes, thread gages, taps. Fischer Special Mfg Co, 446 Morgan Street, Dept PE, Cincinnati 6, Ohio.

(G-33) Fasteners—Catalog, 40 pp. Engineering data on the full line of fasteners with specifications, drawings, and applications. Included are link, hinge and spring lock types, and others. Simmons Fastener Corp, 1751 N Broadway, Albany, NY.

(G-34) Latches—Catalog, 30 pp. Engineering and design information, traceable housings and fittings of complete line of structural latches. All latches shown actual size suitable for tracing. Simmonds Aerocessories, Inc, 105 White Plains Rd, Tarrytown, NY.

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(G-37) Bolts and Self-locking Nuts—Brochure, 4 pp. Materials, finishes, performance specifications and corresponding NAS numbers for lightweight nuts and bolts. Nutt-Shel Co, 2701 S Harbor Blvd, Santa Ana, Calif.

(G-38) Speed Nut—Catalog, 16 pp. Engineering and descriptive data on the most popular types and sizes of speed nut fasteners; also lists sales and service offices. Tinnerman Products, Inc, Dept 14, PO Box 6688, Cleveland 1, Ohio.

(G-39) Specialty Fasteners—Catalog, 48 pp. Specialty fastening devices for aircraft, industrial, electronic, and general applications. Southco Div, South Chester Corp, Lester, Pa.

(G-40) Fasteners—Catalog, 12 pp. Describes lock bolts, blind rivets, tooling for commercial and industrial assembly operations. Specifications and typical applications included. Huck Mfg Co, 2480 Bellevue, Detroit 7, Mich.

(G-41) Special-headed and Thread Fasteners—Bulletin, 4 pp. Rods, bolts, studs, special shapes are shown with size, delivery and ordering information. The Ohio Rod Products Co, Inc, PO Box 26, Berea, Ohio.

(G-42) Flush Catches—Bulletin, 4 pp. Description of models available with specifications, operation data, ordering information. Corbin Cabinet Lock Div of American Hardware Corp, 102 Washington St, New Britain, Conn.

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(G-49) Metal Fasteners—Catalog, 24 pp. Self locking nuts, bolts, screws and special fasteners to commercial and aircraft specifications. The Nylok Corp, 611 Industrial Ave, Paramus, NJ.

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(G-52) Self-locking Nuts and Inserts—Catalog, 32 pp. Contains prints of standard production items and engineering information; also an interchangeable parts list showing equivalents for NAE and AN loknuts. Boots Aircraft Nut Corp, Newtown Turnpike, Norwalk, Conn.

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(G-55) Industrial Adhesives—Catalog, 8 pp. Describes typical adhesives giving primary uses, methods of application and brief specifications. B F Goodrich Industrial Products Co, Adhesives Div, 500 S Main St, Akron 18, Ohio.

(G-56) Fasteners—Brochure, 4 pp. Gives information on principal types of screws, bolts, threaded products, and special cold headed models. Elco Tool and Screw Corp, 1111 Samuelson Road, Rockford, Ill.

(G-57) Shaft-retention Fasteners—Catalog, 18 pp. Explains operational principles; gives applications specifications and design information. Fastex Div, Illinois Tool Works, 195 Algonquin Dr, Des Plaines, Ill.

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(G-62) Pipe Thread Fittings—Catalog, 4 pp. Description and illustration of installation methods, dimensions, prices and weights, operational advantages and applications. Tru-Seal Div, Flick-Reedy Corp, 7N015 York Rd, Bensenville, Ill.

(G-63) Inserts—Catalog, 28 pp. Gives description, engineering information, standard sizes, hole size recommendations, and typical applications. Groov-Pin Corp, 1125 Hendricks Causeway, Ridgefield, NJ.

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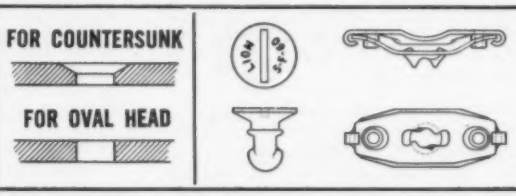

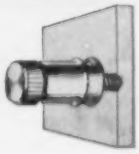

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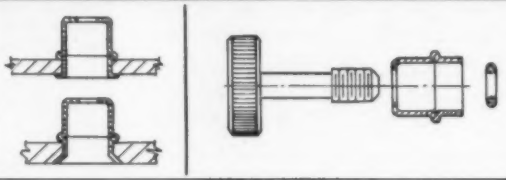

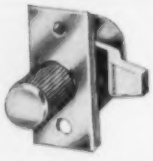

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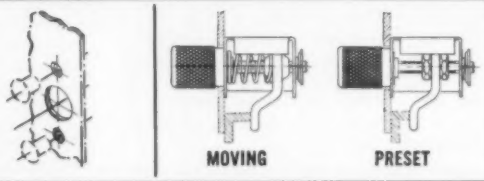

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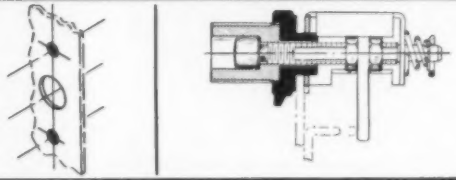

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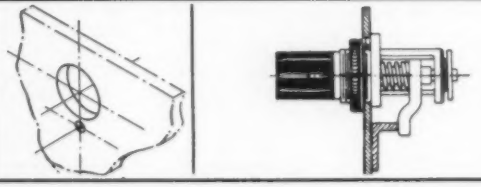

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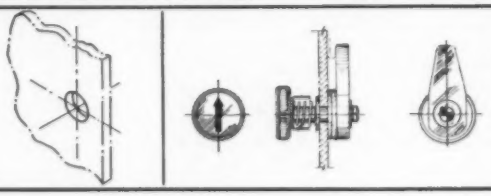

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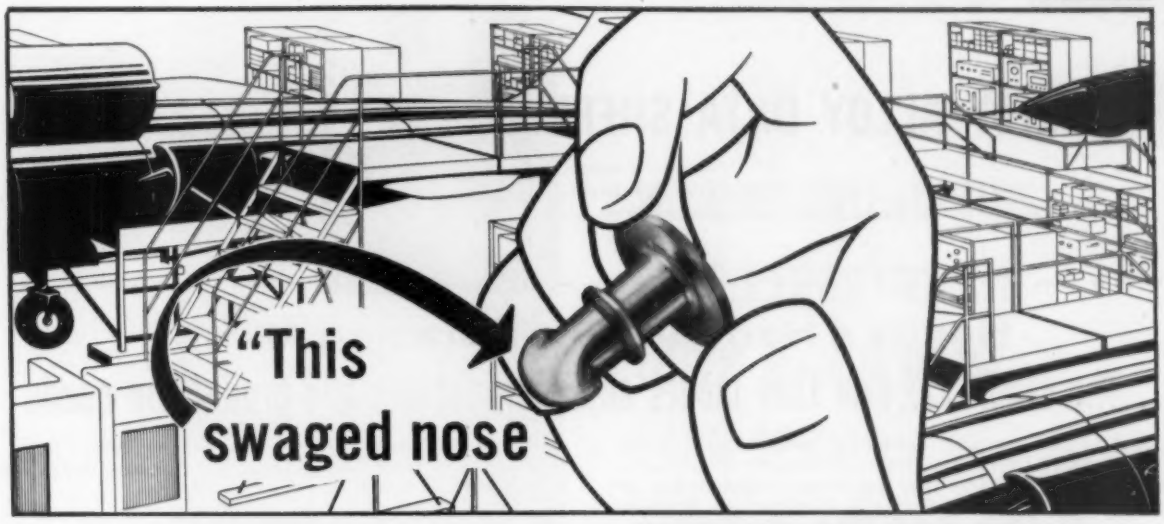
FASTENING AND JOINING



on LION *Quarter-turn* FASTENERS is the secret of reliability, a high strength-weight ratio and smooth, positive operation."

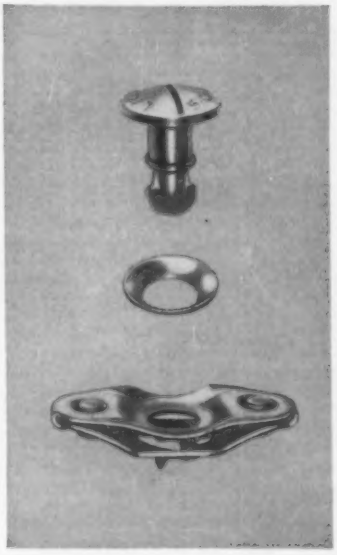
Private, commercial and military aircraft and missile manufacturers' experience with LION QUARTER-TURN FASTENERS for airborne applications and ground operations have justified their choice of these inexpensive, dependable fasteners. They provide quick access through hinged or removable panels. Locking and unlocking is accomplished quickly and smoothly.

Approved for aircraft use—Designed to meet Military Specifications, Lion Quarter-turn Fasteners conform to Mil. Spec. MIL-F-5591A (ASG) . . . are on the Government's QPL . . . are CAA approved for commercial and private aircraft use.

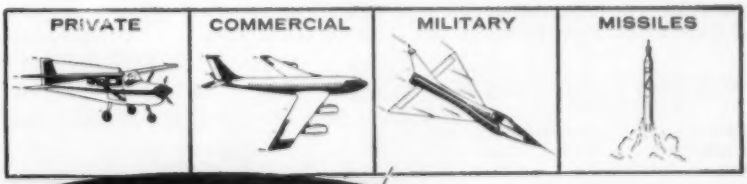
Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud having no cross pins to install or to become misaligned; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

Two types in various sizes available. Model No. 2 is used where space is limited and light weight is essential, Model No. 5 meets severe conditions of shear, tension and vibration.

Full range of heads offers flush, oval, wing, ring, knurled, and notched head and key.



LION *Aviation* **FASTENERS**



one of the SOUTHCO FASTENERS LION

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FASTENING AND JOINING

HANDY ALLOY DATA SHEET

HANDY & HARMAN
ENGINEERING DEPARTMENT
82 FULTON STREET, NEW YORK 38, N. Y.

ALLOY LIST

Handy & Harman Silver Brazing Alloys

...The COMPLETE line that meets all specifications and production needs

Need to join any combinations of metals—ferrous and nonferrous? Investigate the vast number of products, assemblies and parts that are being joined better by silver brazing alloys. Handy & Harman, the Number One Source of, and Authority On Brazing Alloys and Methods makes—and makes readily available—the following silver brazing alloys:

HANDY & HARMAN SILVER BRAZING ALLOYS

NAME		SILVER	COPPER	ZINC	OTHER	MELTING POINT °F	FLOW POINT °F	TROY OUNCES PER CU. IN.
EASY-FLO		50%	15½%	16½%	(18% Cd.)	1160	1175	5.00
EASY-FLO #3		50	15½	15½	(16% Cd. 3% Ni.)	1170	1270	5.00
EASY-FLO 45		45	15	16	(24% Cd.)	1125	1145	4.92
EASY-FLO 35		35	26	21	(18% Cd.)	1125	1295	4.90
SIL-FOS		15	80	—	(5% P.)	1185	1300	4.45
SIL-FOS 5		5	88.75	—	(6.25% P.)	1185	1300	4.37
NEW NAME	**FORMER NAME**	**SILVER**	**COPPER**	**ZINC**		**MELTING POINT °F**	**FLOW POINT °F**	**TROY OUNCES PER CU. IN.**
BRAZE TEC*	TEC*	5	—	—	(95% Cd.)	640	740	4.60
" 056*	TEC-Z*	5	—	16.6	(78.4% Cd.)	480	600	4.53
" 071	SN #7	7	85	—	(8% Sn.)	1225	1805	4.82
" TL	TL	9	53	38		1410	1565	4.50
" 202	AT SPECIAL	20	45	35		1315	1500	4.68
" ATT	ATT	20	45	30	(5% Cd.)	1140	1500	4.64
" NE	NE	25	52½	22½		1250	1575	4.71
" 251	AE	25	57.5	17.5		1255	1625	4.68
" SS	SS	40	30	28	(2% Ni.)	1220	1435	4.76
" 404	SS-5	40	30	25	(5% Ni.)	1220	1580	4.72
" DT	DT	40	36	24		1235	1415	4.80
" DE	DE	45	30	25		1230	1370	4.82
" ETX	ETX	50	34	16		1250	1425	4.99
" 541	ALLOY-4772	54	40	5	(1% Ni.)	1340	1575	5.06
" 560	ER	56	22	17	(5% Sn.)	1145	1205	5.00
" 580	EB	57.5	32.5	—	(3% Mn.- 7% Sn.)	1120	1345	5.05
" RT	RT	60	25	15		1245	1325	5.02
" 603	RT-SN	60	30	—	(10% Sn.)	1115	1325	5.23
" 630	RSNI	63	28.5	—	(6% Sn.- 2.5% Ni.)	1275	1475	5.12
" EASY	EASY	65	20	15		1235	1325	5.06
" MEDIUM	MEDIUM	70	20	10		1275	1360	5.14
" BT	BT	72	28	—		1435	1435	5.24
" HARD	HARD	75	22	3		1365	1450	5.28
" 752	TR #1	75	—	25		1300	1330	5.06
" IT	IT	80	16	4		1345	1490	5.29
" 852	85 Ag.-15 Mn.	85	—	—	(15% Mn.)	1760	1780	5.08

*A Solder—Not a Brazing Alloy

Space does not permit listing the many special alloys, formulated for a particular or unique application. Handy & Harman Brazing Engineers and Technical Service are always ready to work closely with you on metal-joining problems and methods.

Comprehensive technical literature covering all aspects of brazing methods and alloys awaits your request.

GET THE FACTS FROM BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

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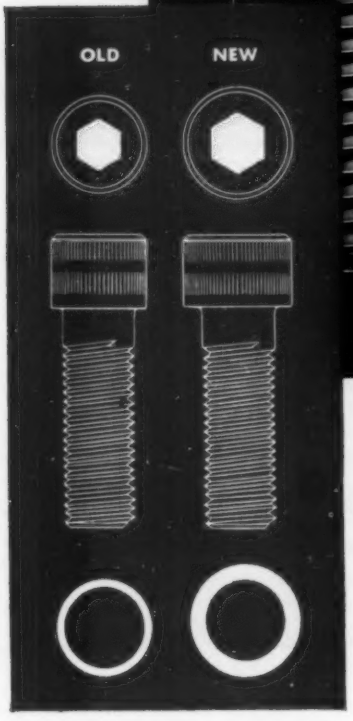

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- LOAD DISTRIBUTED OVER WIDER BEARING SURFACE
- HIGHER PRE-LOADS
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SOLD ONLY THROUGH AUTHORIZED DISTRIBUTORS

Send for your FREE copy of H-K's complete dimensional standard for the new 1960 SERIES. Ask for Form CSN.

WRITE 383 ON READER SERVICE CARD 383

THOMSON TAKES EXTRA PAINS TO PREVENT FASTENING HEADACHES!
Statistical quality control procedures plus 100% inspection give double assurance of close adherence to specified rivet dimensions and positive protection against interrupted production.

YOU GET PRECISION FASTENING AT MASS PRODUCTION COSTS...

. . . when Thomson becomes your fastening partner.

In the Thomson line of more than 8,000 rivet designs, you'll find the semi-tubular, deep-drilled, bifurcated (split), shouldered or compression rivet that will give you the best strength-cost ratio in the fastening field. Produced to the industry's highest quality standards at production rates exceeding 20,000,000 rivets a day, these low-cost fasteners merit serious consideration in your product-improvement and cost-reduction programs.

Our leadership in solving fastening problems with quality rivets and precision rivet-setting machines since 1885 is at your service. What is your problem?

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Rivets and Rivet-Setting Machines

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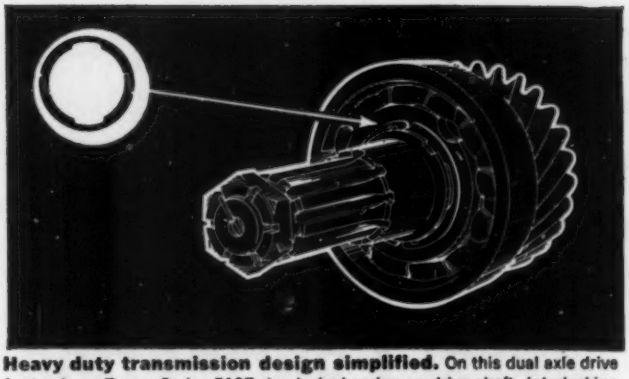


Heavy duty transmission design simplified. On this dual axle drive for trucks, a Truarc Series 5107 ring locks bearing on drive shaft. Interlocking ring design won't dislodge under heavy torque . . . is also recommended for high rpm. applications.

Designing with radially assembled Waldes Truarc retaining rings

solve varied product design problems—save machining, materials, parts and labor

Radially assembled retaining rings, which snap onto a shaft at right angles to its axis, greatly extend the range of products on which retaining rings may be used to simplify design and save parts or labor costs.

For example, rings for radial assembly can be used in applications where it is impossible to install a ring axially over the end of a shaft. Certain types are designed to accommodate shafts of relatively wide tolerances. Others described below may be used to provide a sizeable shoulder on a shaft.

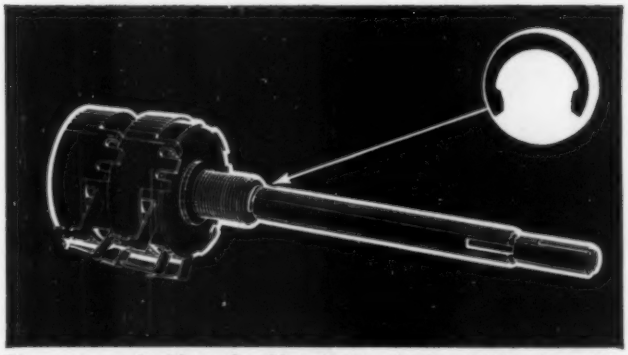
The four applications shown here provide an indication of the wide range of products using radially assembled rings. The rings themselves are basic Truarc types each having specific design features. The high shoulder of one provides a large bearing surface on small diameter shafts; the low shoulder of another is ideal where clearance is limited. A third has an interlocking design which prevents it from being dislodged under torque or high rpm. A fourth can be used against rotating parts at the same time it provides spring tension.

These are but four of Truarc's fifty functionally different types of retaining rings with up to 97 sizes within a single type, six metal specifications and thirteen different finishes. Special hand, magazine, and semi-automatic applicators as well as grooving tools are also available to speed production. The entire line, together with over 70 typical applications, is described and illustrated in the new catalog RR10-58—yours for the asking. And call on us for design assistance on your specific project . . . a Waldes Truarc engineer will be glad to help. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

© 1959 WALDES KOHINOOR, INC.

Rings replace machined shoulders, collars, set screws. That's what original design of this pneumatic temperature transmitter called for. Series 5139 Prong-Lock® ring with bowed design compensates for accumulated tolerances in parts, provides sufficient friction to prevent rotation under vibration. At the same time two Waldes E-rings position and lock adjustment screw to face plate.

Reinforced aluminum ring gives design advantages on louver windows. Waldes Truarc Series 5144 reinforced rings of aluminum secure hinge pins, eliminate costly riveting in linkage of louver type window. Ring design provides large bearing shoulder. Reinforced construction has 5 times the gripping strength of standard E-ring construction, allows use of non-corrosive aluminum.



Ring acts as locking shoulder. Holding the threaded ferrule on this potentiometer shaft is a Truarc Series 5103 Crescent® ring. Crescent ring design with low shoulder provides ample clearance for assembly of panel locknut. It is less costly than a machined shoulder, more effective, quicker to install, easier to remove than the C washer previously used.

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

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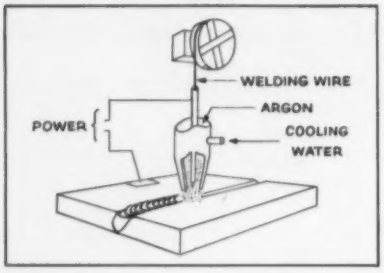
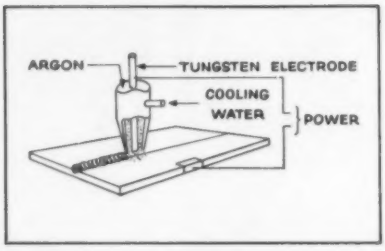
Only LINDE...

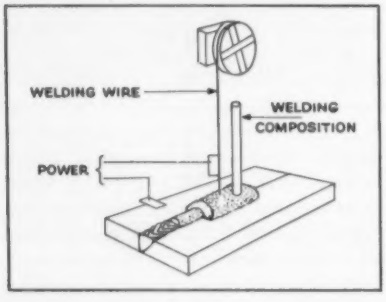
Offers You These Four Advanced Methods for Modern Metal Fabrication



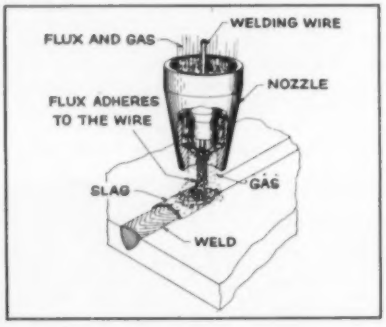
SIGMA Welding—Fastest growing fusion welding method . . . arc is maintained in a shield of argon gas between the consumable electrode filler metal and the workpiece. Welds nearly all commercial metals over ⅛-in. thick manually, and down to 0.050-in. thick automatically.



HELIARC Welding—Makes high quality welds in *any* commercial metal. Uses a non-consumable tungsten electrode in a shield of argon gas. Filler metal may be added to the weld if needed. Since no flux is used, finishing is not necessary.



UNIONMELT Welding—The submerged arc process for welding heavy-duty parts such as pipe, pressure vessels, ships, railroad and industrial equipment. Also used in surfacing for corrosion and wear resistance, and resurfacing for repair.



UNIONARC Welding—Uses new concept of magnetically coating wire with flux at the torch nozzle. Makes high-quality welds in all positions. Also used effectively to repair defects developed during casting or riser-removal on heavy carbon steel castings.

For information or help with any welding problem or to receive LINDE's bi-monthly "Metalworking Bulletin", write Dept. PG-14, Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

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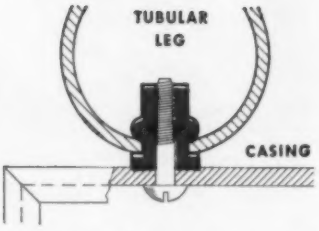
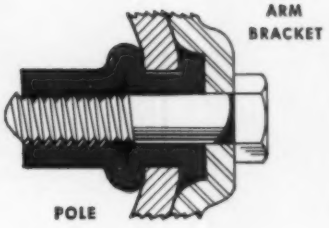
B.F.Goodrich

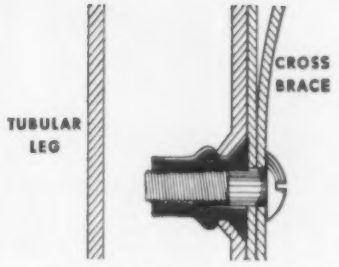
Only B.F.Goodrich Rivnuts® solve all these fastening problems so well



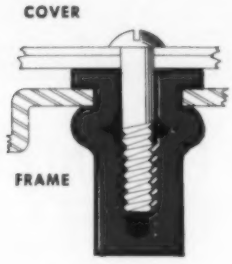
One man installs Rivnuts from one side in seconds—speeds assembly of *barbecues*. Permanent nutplates in legs save time in faster knockdown, too.



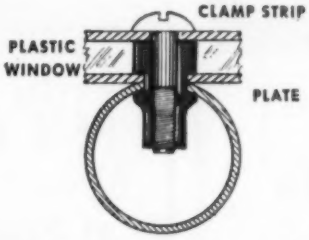
One man does the work of two, assembling arm brackets on *light poles*. Tests show pole or arm will fail before Rivnuts.



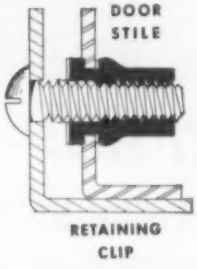
Clean, functional lines of modern *furniture* are preserved by Rivnuts. Upset inside tubular legs, they replace unsightly nuts, bolts and screws.



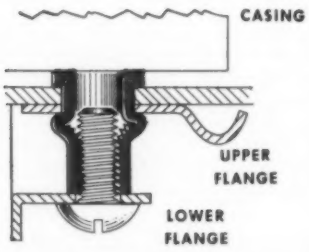
Rivnuts enable repair men to remove top of *automatic washer* and replace it easily. And Rivnuts can be installed after enamelling.



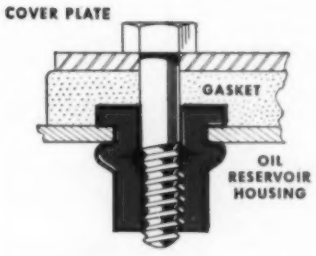
Upset Rivnuts secure *airplane window* plate to center post. Bulges in shanks seal out weather. Heads of Rivnuts serve as spacers for plastic window.



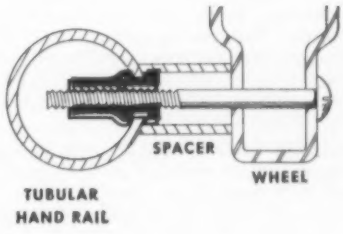
Rivnuts replace self-tapping screws used to hold retaining clips on aluminum *storm doors*, provide firm nutplates that won't loosen with shock or vibration.



Rivnuts eliminate need for reinforcing plates in *vaporizers*. In addition, Rivnuts space bottom flange automatically, prevent bending.



Assembly time for *oil reservoirs* is cut in half. Rivnuts eliminate welding, tapping and cleaning previously required to attach coverplate.



Wheel chair designers needed a blind nutplate with at least 6 clean threads. Rivnuts, only one-piece blind rivets with threads, were the answer.

Special fastening problems? B.F.Goodrich Rivnuts solve them. Send for free demonstrator. Dept. DD, B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.

B.F.Goodrich *aviation products*

WRITE 387 ON READER SERVICE CARD

WRITE 388 ON READER SERVICE CARD→

PEM FIRST NAME IN

Slots (or corrugations) prevent fastener from turning.
Sheet remains flush on opposite side. No swaged rim projects.
Clinching ring squeezes sheet material around back-tapered shank, securely locking fastener.

THE original SELF-CLINCHING FASTENER

Fifteen years ago Penn Engineering and Manufacturing Company introduced the self-clinching fastener, providing load-bearing threads in a wide range of—steel, aluminum, brass and copper sheets, "too thin to thread."

THE ANSWER TO PRODUCTION FASTENING—This unique, exclusive design was immediately recognized as the answer to production fastening by leading manufacturers of aircraft and missiles, automotive, electronic and communication equipment, business machines, farm machinery, electrical appliances, transportation equipment, vending machines, home appliances, etc. Stimulated the cost-conscious sheet metal assembly techniques utilized, today, by many of these manufacturers.

INSTALLED BY A SQUEEZE with the greatest of ease (without special tools) Users tell us that—because the shank of PEM nuts acts as their own pilot . . . because, being round, they require no indexing . . . because they require no special tools . . . because several may be pressed into place in a single operation . . .

THEY SAVE THEIR COST MANY TIMES OVER . . . in time, labor and special equipment. PEM nuts are one of the most profitable items in the assembly line.

Today, PEM Self-Clinching Nuts are made in six types for sheet thicknesses from .030" and up—in steel (with various rust resistant finishes), stainless steel, monel and aluminum. Sizes range from #2 to ¾". Also made as Blind Fasteners for pressure seal applications.

For complete information, write on your letterhead for Bulletin No. CL359 and sample.

Engineered projections. No burnouts in thin sheets.
Round body—no indexing. Compact. Fits on narrow flanges.
Self-locating pilot. Simplified electrodes.
Shank protects threads from weld spatter. No retapping.

specify PEM WELD FASTENERS of Steel or Stainless Steel

PEM Weld Fasteners are designed for production . . . Faster Assembly . . . Lower Equipment and Labor Costs . . . and corrosion resistance, too, when required.

SHANK locates and protects threads against weld splatter . . . eliminates retapping.

ENGINEERED PROJECTIONS prevent burnouts in thin sheets.

SIMPLE ELECTRODES . . . no pilots required.

ROUND COMPACT SHAPE . . . no indexing in assembly . . . fit on narrow flanges.

Write on your letterhead for Bulletin WN-1158 and sample for trial.

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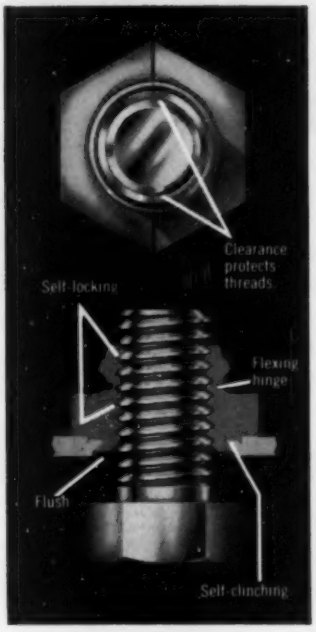
CAPTIVE FASTENERS



ALL-METAL SELF-LOCKING SELF-CLINCHING PEM NUTS

are tops in performance

Combine two essential functions in one lightweight, low-cost unit.

The self-clinching feature is the same tried and proven original PEM design, recognized by industry as the answer to production fastening. It is installed by a squeeze into sheet metal, too thin to thread, by standard pneumatic, hydraulic or mechanical presses.

The all-metal, self-locking feature offers distinct lock-nut design improvements required for top performance under temperature, vibration and stress requirements of such high-reliability services as missile, rocket, aircraft and electronic components.

Exclusive Design • Outstanding Advantages: The All-Metal, Self-Locking features of the new PEM Nut speak for themselves:

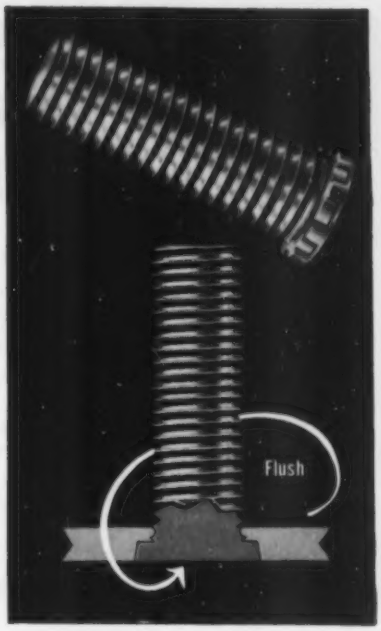
ONE SLOT design: two rugged semi-circular jaws with inherent flexing action—far stronger than several less-supported segments.

FLEXING HINGE: a machined slot at the base of each semi-circular jaw retains inherent flexing action, permanently. Guarantees against relaxation and loosening in severe service. Permits reuse, repeatedly, without diminishing self-locking efficiency.

PROTECTS THREADS: fewer segments—plus relief of cutting edges of single slot design, to provide clearance, insures that *no* cutting edges come in contact with the screw.

Made in #303 stainless steel (temperatures to 800° F); steel (temperatures to 500° F); high strength aluminum alloy (temperatures to 250° F); in sizes from #4-40 to #10-32 for use in aluminum, brass, copper, and cold-rolled steel sheets of thicknesses from .040 up and stainless steel sheets from .050 up.

Write on your letterhead for literature and sample for test.



now PEM SELF-CLINCHING CAPTIVE STUDS

"installed by a squeeze with the greatest of ease"

Answering Industry's demand for a captive stud employing the same unique design as the line of PEM captive Self-Clinching Nuts—which ushered in production fastening in sheet metal assembly—Penn Engineering and Manufacturing Corp. has produced the PEM flush-head self-clinching stud.

Saving time, labor, weight on tough assembly jobs, these studs make a surprisingly simple operation out of what formerly was accomplished by various slow and costly makeshift assembly methods, such as welding.

You simply place the studs—one or several at a time—into drilled or punched holes in the panel and squeeze them into place with any standard pneumatic or oil-hydraulic squeezer or mechanical press.

The squeezing action embeds the head projections into the sheet—the displaced metal flowing smoothly and evenly around the back-tapered shank and annular groove to securely lock the stud into the panel with high torque and pushout resistance.

Try them. Write on your letterhead for literature and sample. Sizes from #4-40 to 5/16-18. Carbon steel or #305 stainless steel, for use in various aluminum alloys, brass, copper, cold rolled steel and similar sheets in thicknesses from .040 up.

PEM

CORPORATION, DOYLESTOWN, PENNSYLVANIA

Kansas City, Mo.—Grand 1-6314
Birmingham—State 5-5761
Phoenix—Whitney 5-0680
Dallas—Fleetwood 7-5713
Los Angeles—Bradshaw 2-8097
Miami—Tuxedo 8-4570

FASTENING AND JOINING

Why waste skilled hands on orienting, feeding, assembly?

Reduce "man"-handling of small parts

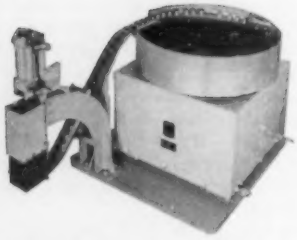
. . . with DPS machines

There's no need to squander valuable manpower on the tedious, monotonous tasks of assembling small parts. Detroit Power Screwdriver Company has machines to do these jobs automatically, effortlessly!

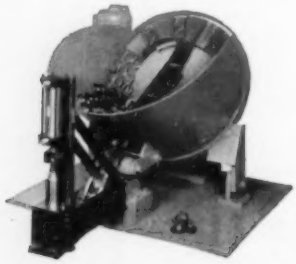
In hundreds of applications, DPS machines (selective feeders, screwdriving and special assembly machines) have slashed production costs. Besides freeing skilled hands for more productive work, they simplify operations . . . minimize errors and damage . . . assure a high-quality finished product.

Detroit Power Screwdriver Company will gladly analyze your problems . . . propose the solution from industry's most complete line of selective feeders and screwdriving machines, products of more than three decades of specialization. Write today for full information. *CATALOGS AVAILABLE ON ALL MACHINES!*

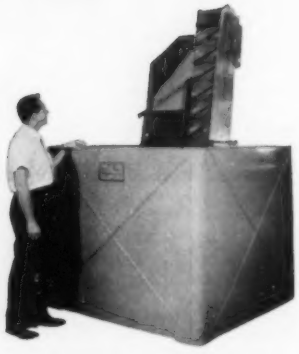
NEW DPS MODEL "U" — For fast, clean driving of screws, nuts, studs. The Model "U" is industry's most advanced screwdriving machine . . . can drive screws ranging from #6 x 3/16" long to 1/4" x 1 1/2" long, and can be equipped with 12" or 16" feeders.



VIBRATORY FEEDER — Designed for light, fragile or highly finished parts that must be handled gently . . . cannot withstand excessive tumbling.



ROTARY FEEDER — For high-production feeding of more durable parts in a wide variety of sizes and shapes.



ELEVATING FEEDER — Offers variable feeding rates and discharge heights to match your requirements. 6, 12 and 20 cu. ft. holding capacities.

DETROIT POWER SCREWDRIVER COMPANY

15,214

2821 W. Fort St. Detroit 16, Michigan

A Subsidiary of Link-Belt Company

HOW MANY WAYS CAN *Special Purpose Fasteners* CUT COSTS FOR YOU?

How many of your products employ laborious, old-fashioned fastening methods where simple fasteners could do the job and cut costs, too? How many parts and sub-assemblies can be adapted to include a self-fastening feature? How many future products could be improved by advance planning for fastener efficiency?

United-Carr's engineering staff offers you a wealth of experience in the design of special-purpose fasteners and self-fastening devices. Large-scale manufacturing facilities (including in-plant plastics molding equipment) ensure economical, *volume* production and prompt deliveries. United-Carr field representatives are ready to call on you at *your* request.

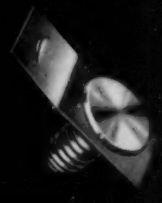
POLYETHYLENE MOUNTING FOOT

No mar, no scratch glide for use on TV receivers, record changers, small appliances, etc. Assembles into round hole in wood or metal cabinets.

NYLON SNAP-IN NUT

Snaps into square hole stamped out of sheet metal . . . provides secure anchorage for any sheet metal or self-tapping screw . . . highly effective electrical insulator.

QUICKEY FASTENER



Eliminates need for welding or swaging studs to sheet metal stampings, facilitates nesting, eliminates damage in transit because Quickey snaps in before final assembly.

THREAD CUTTING FASTENER

Re-usable, self-locking, vibration-proof fastener cuts clean, deep threads on unthreaded chrome-plated studs. Available for ⅛", 5/16" and ¼" studs. Can be driven with standard wrenches.

PLUG BUTTONS

Snap into ⅛" to 3" dia. holes. Can be embossed with ornamental or functional designs . . . various finishes, shapes and sizes.

WIRING FASTENER

Mounting legs snap into round hole . . . provide secure anchorage. Body of fastener holds wires without chafing.

MOLDING FASTENER

Ideal for use with thread cutting fasteners or available with threaded stud for nut and lock washer assembly. Spring leg maintains tension to keep fastener blade locked in molding channels.

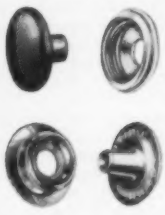
TEENUT

One-piece, all-metal nut has welding bosses on upper or lower surface of mounting flange. Has high tensile strength and provides secure, permanent anchorage for bolt. Available in various shapes and sizes.

TRIMOUNT STUDS

Hold two or more thicknesses of material together. Easily installed by hand. Insure vibration proof attachment. Permanent or removable. Many shapes and sizes.

DURABLE DOT FASTENER



Snap fastener for cloth, leather, plastics and other materials. Positive closure, instant release. Black, nickel or brass finish.

CARR FASTENER COMPANY

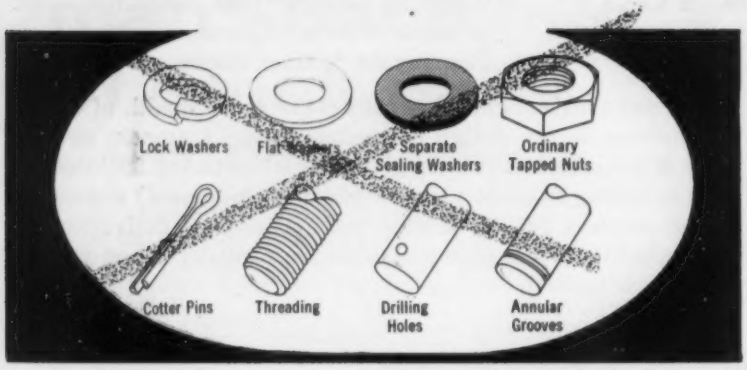
Division of United-Carr Fastener Corp., Cambridge 42, Massachusetts

MAKERS OF DOT FASTENERS

FASTENING AND JOINING

PALNUT® LOCK NUTS and FASTENERS *Eliminate*

one or more of these assembly parts or operations



– and provide compact, vibration-proof assemblies

PALNUT Lock Nuts for Threaded members

Spring tempered steel Palnuts, with the dependable double-locking thread form, are available in many stock types and sizes to meet practically any assembly need. Here are typical advantages:

- **Low cost**—less than other locking devices, often less than plain nuts.
- **Easy, fast assembly** with ordinary manual or power tools, extra fast with Palnut Magnetic Wrenches.
- **Save Parts.** One Palnut replaces 2, 3, even 4 parts according to application.
- **Save Space** by eliminating auxiliary parts.
- **Save Weight**—up to 85% reductions in fastener weight.
- **May be removed and re-used.**

FASTENERS for Unthreaded Studs, Rods, Pins, etc.

SELF-THREADING NUTS

Save threading costs. Form their own deep, clean threads while tightening on studs of any malleable material, including aluminum or zinc die-cast; also rods, shafts, wire or pins of steel, aluminum, brass or plastic. Fast assembly with standard tools. Vibration-proof grip, whether seated or unseated. Remove and reuse on same studs. Sizes for 1/4", 5/32", 3/16" and 1/4" dia. Write for Bulletin 585-A.

PUSHNUT® FASTENERS

Simply push on unthreaded studs, rod, wire or rivets. Strong spring grip resists removal. Save threading, grooving, drilling for cotter pins. Low in cost, fast assembly. Many types and sizes.

Write for Catalog 573-C and Free Samples, stating type, size and application.

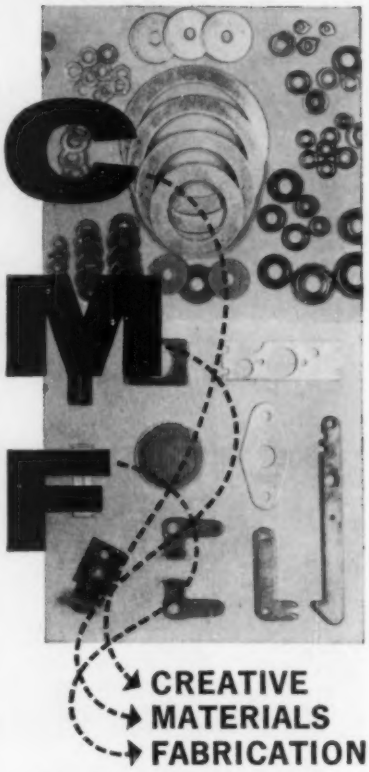
THE PALNUT COMPANY, 65A Glen Road, Mountainside, N. J.
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

PALNUT® LOCK NUTS FASTENERS PAL

Quick, secure fastening at low cost

392 WRITE 392 ON READER SERVICE CARD

A BARWOOD SPECIALTY



Stamped, punched and die cut parts, designed and produced to your specifications is a BARWOOD specialty. Working with all types of metals, fibrous materials, synthetics, Nylon, Teflon, phenolics, etc., our plant produces a wide range of parts for the most exacting requirements.

BARWOOD has developed many innovations in fastening and sealing methods that have substantially reduced assembly costs in customer plants.

RELY ON BARWOOD FOR
•
PRECISION METAL STAMPINGS
•
STANDARD AND SPECIAL WASHERS
•
GASKETS • PACKINGS
DIE-CUT PARTS • SHIMS • SPACERS

. . . our automated production facilities integrated with your assembly schedules mean more profitable productivity for you.

Find out how **CMF** *can help — write for Bulletin B-500 — just off the press.*

WASHER BARWOOD MADE
Established 1900

L.J. BARWOOD
MANUFACTURING CO., INC.
130 Williams Street
Everett 49, Mass.

WRITE 646 ON READER SERVICE CARD

catalogs and bulletins.....continued

(G-65) **Toggle Clamps**—Catalog, 14 pp. Complete line exhibited with working drawings of each model and accessories. West Point Mfg Co, 26935 W Seven Mile Rd, Detroit, Mich.

(G-66) **Retaining Rings**—Catalog, 24 pp. Lists standard ring sizes and examples of specially designed rings. Also information on materials and finishes, government and industry standards. Waldes Kohinoor, Inc, 46-16 Austel Place, Long Island City 1, NY.

(G-67) **Fastening System**—Brochure, 15 pp. Describes the tool, installation method and the locking action. Provides diagrams, selection chart and sample specification sheets. Voi-Shan Mfg Co, 8643 Higuera St, Culver City, Calif.

(G-68) **Hex Socket Screws**—Catalog, 40 pp. Describes line of hex socket set and cap screws, dowel pins, pipe plugs and nuts. Includes dimension standards and basic uses. The Allen Mfg Co, Drawer 570, Hartford 1, Conn.

(G-69) **Screws and Special Fasteners**—Catalog, 126 pp. Gives head styles, dimensions and finishes for wood, drive, machine and tap screws, stove bolts and special fasteners with suggested hole sizes and shipping data. Continental Screw Co, 459 Mt Pleasant St, New Bedford, Mass.

(G-70) **Fasteners**—Catalog, 23 pp. Provides assembly diagrams, specifications, and installation instructions for various studs, brackets, and other fasteners. Fastex Div, Illinois Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-71) **Fasteners**—Catalog, 15 pp. Quarter turn spiral cam self-locking fasteners and ¾ turn fastener with rapid four lead thread for shear and tensile loads. Includes installation tools and methods. Dzus Fastener Co, Inc, Babylon, NY.

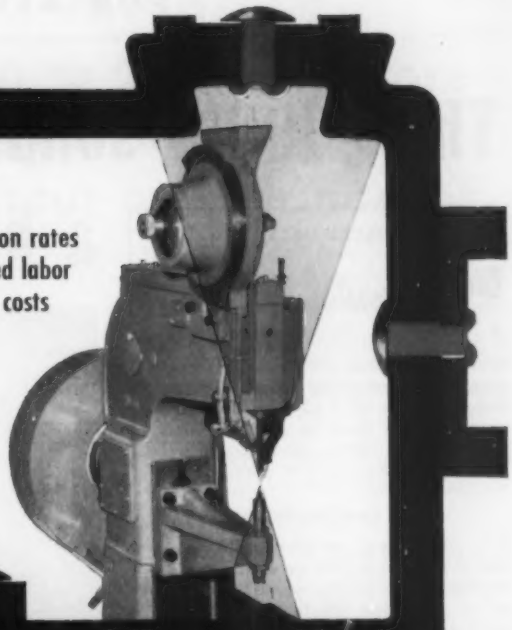
(G-72) **Welding Fasteners**—Brochure, 8 pp. Describes externally and internally threaded parts, applications and engineering information. Central Screw Co, 3501 S Shields Ave, Chicago 9, Illinois.

(G-73) **Panel Fastener**—Bulletin, 9 pp. Results of qualification tests given according to National Aircraft Standards. Includes baking, shear fatigue and vibration cycling tests. Waldes Kohinoor, Inc, 47-16 Austel Place, Long Island City 1, NY.

(G-74) **Self-threading Nuts**—Brochure, 8 pp. Includes assembly data, torque-tensile factors, dimensions and typical applications. Principles of operation are illustrated. The Palnut Co, Glen Rd, Mountainside, NJ.

(G-75) **Place Bolt**—Brochure, 6 pp. Describes special head design, wrench torque factors and the application of one piece, self-locking hex head bolt. Provides data on production line torque and comparison with standard bolts. The Lamson & Sessions Co, 5000 Tiedeman Rd, Cleveland 9, Ohio.

Odd shapes are no problem for the new Townsend Model 75 Tubular Rivet Setting Machine



High production rates using unskilled labor cut fastening costs

Skillfully designed tooling gives complete versatility to the new Townsend Model 75 Tubular Rivet Setting Machine. A variety of specialized tooling is available to equip the Townsend machines for any size and shape of work.

Townsend tubular rivets are available in steel, aluminum, copper, brass, nickel-silver and special materials for use in joining anything from cloth to steel sheets. Thus, Townsend makes available the economies of tubular rivet fastening for a wide range of products in a number of different materials. Townsend's experienced fastening engineers provide application design service.

If you wish to enjoy the economies of fastening with tubular rivets, write for complete information on the versatile Model 75 Setting Machine and the complete line of Townsend tubular rivets. Townsend Company, P. O. Box 71-D, Ellwood City, Pa.

Townsend Company

Engineered Fasteners Division

ELLWOOD CITY · PENNSYLVANIA

In Canada: *Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario*

WRITE 393 ON READER SERVICE CARD 393

News about R&A SINCE 1913 **Adhesives**

FOR ALL METALS AND ALL PLASTICS

This "100%-solids" adhesive flows like a heavy-bodied motor oil

TECHNICAL DATA ON

Bond*master*® M648T

A free-flowing, high strength, room-temperature-curing, 100%-reactive, two-component, formulated epoxy adhesive designed for bonding all metals and other rigid materials (such as glass, ceramics, plastics, plastic foams, and structural laminates) to themselves and to each other.

BOND CHARACTERISTICS

Fully cured bonds exhibit minimal shrinkage, are electrical insulators, and provide excellent resistance to weather, galvanic action, and most chemicals, acids, and alkalies.

APPLICATION

Mixed BONDMASTER M648T may be applied with trowel, spatula, knife, roller, brush, etc. Apply enough *mixed* BONDMASTER 648T to fill all cavities and depressions in both surfaces *and* to leave about 4 additional mils of adhesive on each side. Press together firmly to establish and maintain intimate contact, and cure. Pressure is not required during cure.

SPECIFICATIONS

VISCOSITY (mixed): about 10,000 cps. COLOR: clear, pale amber. BASE: modified epoxy. SOLIDS: 100%. HARDENERS: CH-8 for balance of all properties; CH-16 for best shock and peel strengths. WEIGHT PER GALLON: about 10 lbs. STORAGE: 1 year, unmixed. CONTAINERS: 1-gal. cans; 5-gal. pails; 55-gal. drums.

R&A SINCE 1913

RUBBER & ASBESTOS
CORPORATION
222 BELLEVILLE AVENUE
BLOOMFIELD, NEW JERSEY

Don't let the "100%-solids" term confuse you . . . this modified epoxy adhesive is a free-flowing liquid!

BONDMASTER M648T ("T" for "thin") exhibits all the smooth mixing characteristics and ease of handling of a 10,000 cps fluid—can be applied by brush, spatula, roller, spreader, or similar conventional equipment.

As with all BONDMASTER formulated epoxy adhesives, M648T yields high strength bonds on all rigid metals and just about any plastic or plastic laminate. In addition, its lower viscosity makes it ideally suited for work on flexible plastic sheets (like bondable Teflon) or fragile cells of rigid plastic foams (like Styrofoam) as well as on thin metallic foils of all types.

100% REACTIVE

The glue line thickness you put down won't shrink, either during the cure or after it . . . this formulation is 100% reactive. (There is no wait for solvent evaporation either.) Mere contact pressure is sufficient.

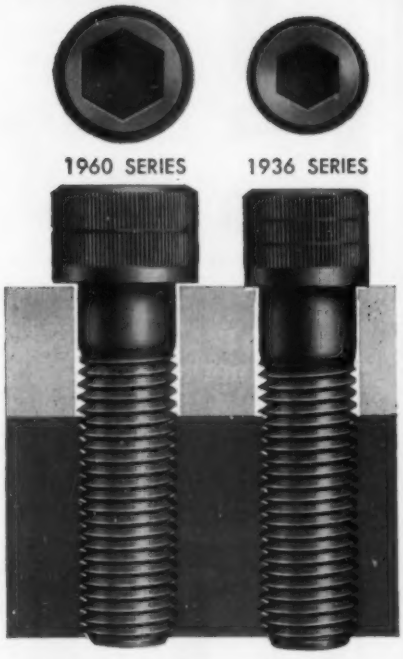
CURES AT ROOM TEMPERATURE

A bond that's strong enough to permit handling of your assembly develops at room temperature in from 4 to 6 hours; about 85% of maximum strength in less than one day. Alternately, if you can heat-cure, you can reach full strength far more rapidly—in as little as 10 minutes at 250°F., for example.

WRITE FOR FURTHER DATA

Write for Technical Data Sheet describing this 100%-reactive, free-flowing liquid epoxy adhesive formulation. We will be glad to send a free evaluation sample as well if you will describe your bonding problem in detail.

Allen's New '60 Series Socket Head Cap Screws



give up to 2⅓ times more load carrying capacity ...without indentation!

In Allen's new '60 Series, head diameter of sizes from ¼" up is now uniformly one and one-half times the body diameter. In many sizes (where this ratio was not called for by 1936 Series specifications) this will provide *more* under-the-head bearing surface, and a proportionate *increase* in clamping force. Loads are more evenly distributed, and the greater bearing area in many cases eliminates need for washers.

Socket sizes have been increased in many cases—greater wrenching area permits higher tightening torque—which resists fatigue failure, and lengthens the life of the threaded joint.

- A new 2-band knurl will identify all ALLEN Cap Screws (except Stainless Steel) that conform to the new '60 Series specifications. New labels on boxes will also identify these.
- The 1936 Series of Allen Cap Screws will continue to be available.

COMPARISON OF ALLEN 1960 SERIES AND 1936 SERIES SOCKET HEAD CAP SCREWS

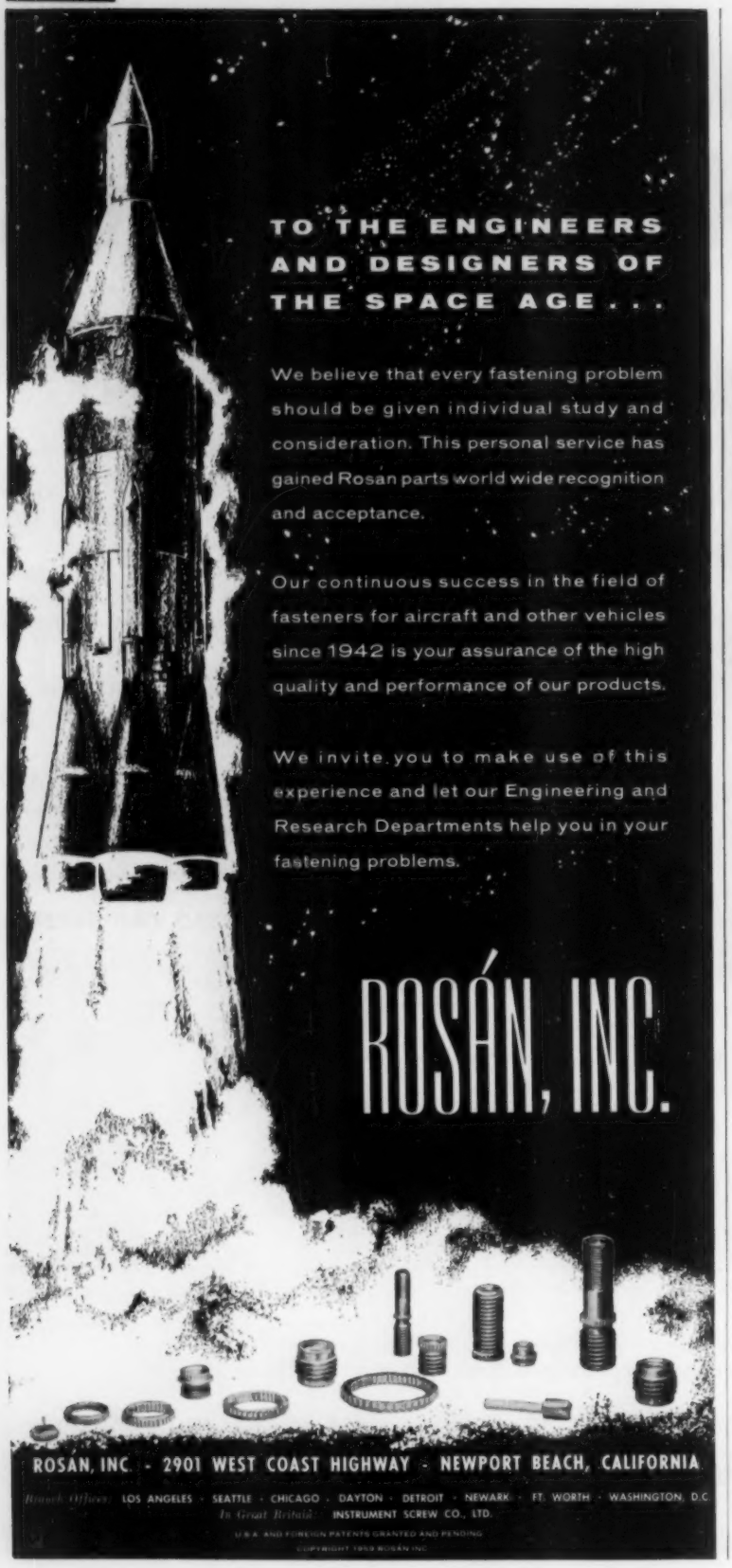
SCREW SIZE	HEAD DIAMETER Minimum (inches)		BEARING SURFACE Minimum (square inches)		PERCENT OF INCREASE IN BEARING SURFACE[1]	TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)		TORQUE INDUCED TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)	
	1960 Series	1936 Series	1960 Series	1936 Series		1960 Series	1936 Series	1960 Series	1936 Series
¼	.365	.367	.044	.044	—	4,750	4,750	2,780	2,780
5/16	.457	.429	.070	.052	33	7,440	5,600	4,380	3,300
3/8	.550	.553	.111	.111	—	12,100	12,100	7,000	7,000
7/16	.642	.615	.140	.103	36	15,000	11,000	8,850	6,450
½	.735	.739	.183	.183	—	19,500	19,500	11,500	11,500
5/8	.921	.863	.293	.216	35	31,000	23,200	18,500	13,600
¾	1.107	.987	.424	.224	89	45,000	24,000	26,700	14,100
7/8	1.293	1.111	.585	.253	131	62,500	27,000	36,800	15,900
1	1.479	1.297	.768	.405	89	82,000	43,500	48,500	25,500

[1]Head tolerance revisions on Sizes #0 thru #10, ¼, 3/8, and ½ diameter have no significant effect on bearing surface or holding power of screws.
[2]Values based on .00025 inch indentation.

Ask your Industrial Distributor about ALLEN '60 Series Cap Screws.
Write for samples and complete specifications. Ask for Bulletin G-25.

ALLEN MANUFACTURING COMPANY
Hartford 1, Connecticut, U.S.A.
Stocked and sold by leading industrial distributors everywhere

ALLEN HEX-SOCKET SCREWS HEAD


TO THE ENGINEERS AND DESIGNERS OF THE SPACE AGE . . .
We believe that every fastening problem should be given individual study and consideration. This personal service has gained Rosan parts world wide recognition and acceptance.
Our continuous success in the field of fasteners for aircraft and other vehicles since 1942 is your assurance of the high quality and performance of our products.
We invite you to make use of this experience and let our Engineering and Research Departments help you in your fastening problems.
ROSÁN, INC.
ROSAN, INC. - 2901 WEST COAST HIGHWAY - NEWPORT BEACH, CALIFORNIA
Branch Offices: LOS ANGELES · SEATTLE · CHICAGO · DAYTON · DETROIT · NEWARK · FT. WORTH · WASHINGTON, D.C.
In Great Britain: INSTRUMENT SCREW CO., LTD.
U.S.A. AND FOREIGN PATENTS GRANTED AND PENDING
COPYRIGHT 1960 ROSAN INC.

396 WRITE 396 ON READER SERVICE CARD

Nylok-Detroit is fully equipped to add locking, sealing, adjusting nylon inserts to any threaded part—*regardless of size, shape or material!* What's more, you may furnish your own parts to have the pellet inserted—or purchase complete parts processed to your exact specifications.

Special equipment geared to handle both long and short production runs assures maximum efficiency and economy. Send sample, blueprint or description for prompt quotation and delivery.

Also sold through selected industrial supply houses

NYLOK DETROIT CORP.
Dept. 11 1100 N. Woodward Ave., Birmingham, Michigan

"NYLOK" is a registered trade-mark of The Nylok Corporation.

WRITE 647 ON READER SERVICE CARD

FASTENING AND JOINING

catalogs and bulletins.....continued

(G-76) **Fasteners**—Brochure, 11 pp. Describes recess applied to bolts, screws and other turning fasteners. Lists advantages and sample specifications and includes selection chart. Voi-Shan Mfg Co, 8643 Higuera St, Culver City, Calif.

(G-77) **Rivets**—Catalog, 16 pp. Types, sizes, installation procedure, tools, test data on internally threaded tubular rivets. B F Goodrich Aviation Products, 500 S Main St, Akron, Ohio.

(G-78) **Screw Lock Inserts**—Catalog, 8 pp. Design data, specifications for screw lock inserts and installation tools. Heli-Coil Corp, Shelter Rock Lane, Danbury, Conn.

(G-79) **Fixture Clamps**—Catalog, 14 pp. Specifications, dimensions, drawings and discount rates for clamps, washers, bolts and others. West Point Mfg Co, 26935 W Seven Mile Rd, Detroit 19, Mich.

(G-80) **Welding Equipment**—Catalog, 16 pp. Describes various manual torches available for inert-gas tungsten-arc welding. Also, includes accessory and related equipment. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY, NY.

(G-81) **Special Thread**—Brochure, 4 pp. Sketches show how thread forms the mating surface in parts or assemblies. Representative strength chart, cross section view and applications. The Lamson & Sessions Co, 500 Tiedeman Rd, Cleveland 9, Ohio.

(G-82) **Bolts and Capscrews**—Brochure, 4 pp. List of products produced, including standard and special aircraft fasteners, facilities and laboratory control. Chandler Products Corp, 1491 Chardon Rd, Cleveland 17, Ohio.

(G-83) **Vehicle Hardware**—Catalog, 73 pp. Describes line of truck body fittings such as hinges, door and compartment locks, seat pedestals, and others. Eberhard Mfg Co, Div of The Eastern Malleable Iron Co, 2734 Tennyson Rd, Cleveland 4, Ohio.

(G-84) **Self-locking Fasteners**—Catalog, 16 pp. Lists fastener applications and shows how the operating principle is applied to bolts, set screws and special fasteners. Gives materials, sizes and finishes. The Lamson & Sessions Co, 5000 Tiedeman Rd, Cleveland 9, Ohio.

(G-85) **Fasteners**—Brochure, 4 pp. Illustrates complete line of fasteners and explains process heat treatment. Also contains information on quality control and delivery. Standard Screw Co, 2701 Washington Blvd, Bellwood, Ill.

(G-86) **Die Cast Industrial Fasteners**—Catalog, 8 pp. Pictures and specifies standard and special die cast zinc and molded nylon fasteners. Wing nuts, cap nuts, rivets, thumb nuts, thumb and wing screws are included. Nylon parts covered are machine screws, set screws, washers and special fasteners. Gries Reproducer Corp, 125 Beechwood Ave, New Rochelle, NY.

THE

CP

ON EVERY

CHANDLER

CAP SCREW

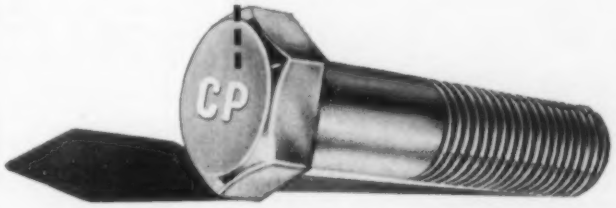
IS YOUR

GUARANTEE OF

QUALITY

UNIFORMITY AND

PRECISION!



This trademark — *CP* — is your assurance of engineered quality from start to finish . . . your guarantee of functional dependability . . . your security that every cap screw has successfully met rigorous performance tests. Chandler Products . . . manufacturers of standard and special fasteners for over 30 years . . . mass-produces cold-headed cap screws from high carbon, alloy, super-alloy and stainless steels. *Check with Chandler* before placing your next order.

CP

Write today for your copy of CHANDLER PRECISION FASTENERS

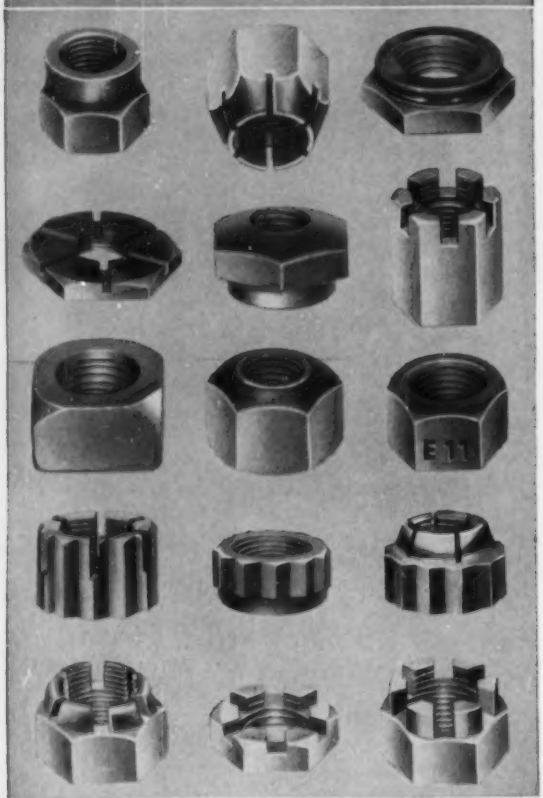
chandler products corporation 1497 Chardon Road • Cleveland 17, Ohio

8838-CH

SPECIAL NUTS

to specs. 7/16"—4¼" cross flats

special machines + large stock of material × years of experience = speedy deliveries high quality low prices



Here are a few samples made to customers specifications . . Our batteries of special high-speed multi-spindle, automatic machines make possible fast and accurate production of hexagon nuts of non-standard height and special shape from carbon or alloy steel, Naval bronze or other non-ferrous metals; also AN 310 through AN 335 as per latest Airforce specifications. Very often the special nut you require may be similar to one we are already making and a simple modification would result in a price advantage and quicker deliveries to you . . Send us your blueprint and particulars —let us quote on your requirements . . We also have a catalog that contains complete specifications, engineering data and prices regarding our standard nuts.

*12 Pointer Standards, sizes: ¼" to ¾"—brochure on request

NATIONAL MACHINE PRODUCTS

*Manufacturer of Standard and Special *12 Pointer and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.*

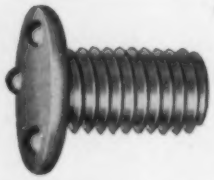
44225 Utica Rd., UTICA, Michigan

an sps COMPANY

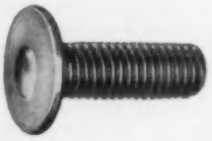
OHIO WELD SCREWS

AS THE PRIMARY FASTENERS IN FASTENER ASSEMBLIES MEAN . . .

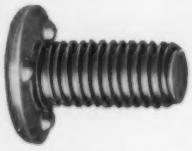
- **LIGHTNING-FAST APPLICATION BY RESISTANCE WELDING**
- **PRIMARY FASTENER PERMANENTLY POSITIONED**
- **SPLIT-SECOND ASSEMBLY OF PRODUCT COMPONENTS—MADE POSSIBLE BY PREATTACHED PRIMARY FASTENER**



GW SCREWS—Used where design requires a smooth unmarred surface and a fastener permanently fixed in place.

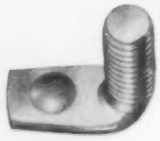


HH SCREWS—Used where a single, button-type projection is required when welding to curved surfaces, to heavy sheet 3/32" or thicker, or to ends of rods.



HW SCREWS—Used where a self-locating through bolt is required to be fixed securely in place so that it will not turn and flush surface is required for attaching mating parts.

RW SCREWS—Used where a hermetic seal is required to prevent leakage of air, gas, water, oil or dust, or when welding to perforated metal or wires.



DW SCREWS—Used where a projection weld screw is required and confined location necessitates a narrow head.

SS SCREWS—Used where a screw with narrow head is required to be spot welded in place.

PD SCREWS—Used where it is desirable to place a threaded section on the edge of a sheet.

CS SCREWS—Used where a hermetic seal and a screw are needed on both sides of the sheet as on transformer can relay points.

Samples and information furnished upon request.

The OHIO WELD FASTENERS Primary Fastener in Fastener Assemblies

THE OHIO NUT AND BOLT CO.

41 FIRST STREET BEREA, OHIO

catalogs and bulletins.....continued

(G-87) **Screws**—Catalog, 31 pp. Presents dimensional standards, strengths, applications and physical properties of various screws, pipe plugs, pins, and others. The Bristol Co, Socket Screw Div, Waterbury 20, Conn.

(G-88) **Resorcinol Formaldehyde Adhesive**—Bulletin, 4 pp. Tells how to use room temperature adhesive which curves to produce water-resistant bonds. Meets Mil Spec MIL-A 397-B, as Type II, Grade D, Class 1 Adhesive. Can be used for exterior grade plywood. Reichhold Chemicals, Inc, White Plains, NY.

(G-89) **Rivet-bolts**—Catalog, 6 pp. Lists advantages of ribbed-type bolt and self-locking nut for structural connections. Photographs and sketches show locking principles for the nut and bolt application methods. Prices, dimensions and weights. The Lamson & Sessions Co, 5000 Tiedeman Rd, Cleveland 9, Ohio.

(G-90) **Hose Clamp**—Brochure, 4 pp. Gives materials, plating information, thicknesses, installation tools and procedures. Designed for low pressure applications. Cuyahoga Products Corp, 10252 Berea Rd, Cleveland, Ohio.

(G-91) **Rivets and Setting Machines**—Catalog, 15 pp. Describes representative group of standard tubular, split and shoulder rivets; engineering data and automatic equipment for setting. Chicago Rivet & Machine Co, 950 S 25th Ave, Bellwood, Ill.

(G-92) **Clamps**—Catalog, 43 pp. Describes various clamps, clips, assemblies, and others. Gives materials, specifications, heat treatment and finishes. Universal Metal Products, Inc, 331 N Vineland Ave, La Puente, Calif.

(G-93) **Riveting System**—Bulletin, 4 pp. Describes the operation of high-speed automatic equipment and typical applications. Also, covers types of rivets, materials and speeds. Aviation Development Inc, 210 S Victory Blvd, Burbank, Calif.

(G-94) **Stud-welding Method**—Catalog, 20 pp. Design recommendations for stud welding method of fastening, including stud locating procedures, strengths, and other technical information. Nelson Stud Welding Div of Gregory Industries, 28th St & Toledo Ave, Lorain, Ohio.

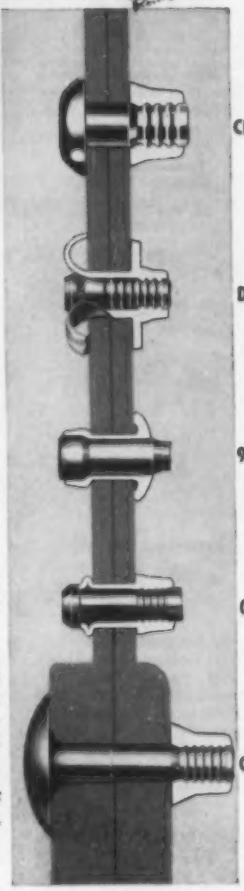
(G-95) **Socket Head Cap Screws**—Catalog, 4 pp. Describes new engineering standards effecting socket screws. Ratio of head diameter to body diameter, minimum thread length and socket width have been changed in several models. Gives comparison chart, materials and specifications. The Holo-Krome Screw Corp, Hartford, Conn.

(G-96) **Manual-welding Torch**—Brochure, 4 pp. Gives details on torch for inert-gas consumable-electrode welding. Welding wire spool is mounted on the torch. Linde Co, Div of Union Carbide Corp, 30 E 42nd St, NY, NY.

the smart move

is to **HUCK**

FASTENERS



Comments of regular users of HUCK FASTENERS tell the story.

"70% saving in our assembly cost".

"50% faster than previous methods".

"We use them wherever possible because of their strength and sealing qualities".

"Every fastener is automatically "torqued" identically".

"They don't slip, strip or wear loose".

Thousands of smart manufacturers have discovered that HUCK fasteners are truly the BETTER way to do their fastening job.

So mechanically predetermined is the result of the HUCK fastening system that unskilled operators can produce professional grade work almost immediately, at up to thirty fasteners per minute. Materials, sizes and head styles to meet your specific requirements.

Give us your fastening problems, our years of experience are at your service.

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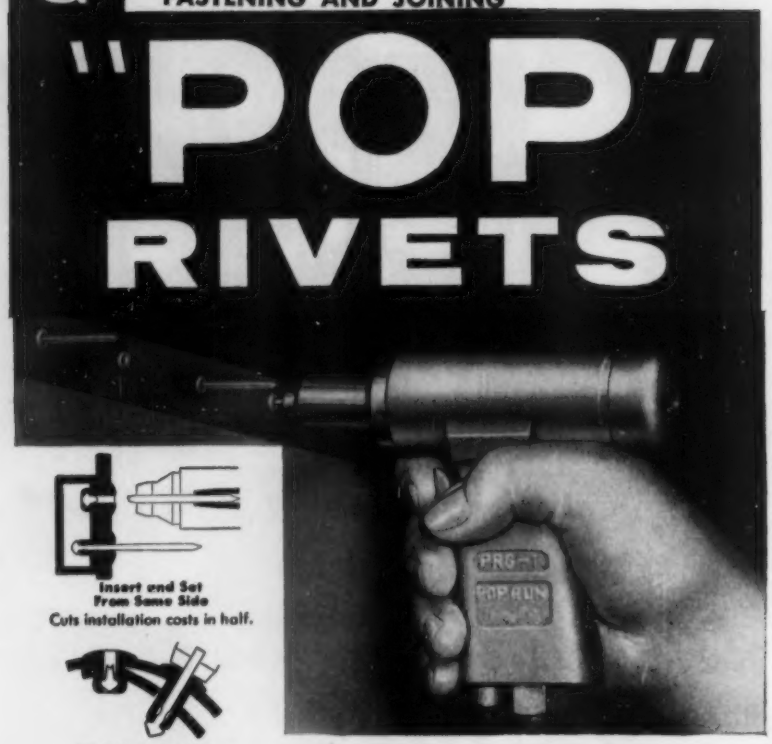
"POP" RIVETS



Insert and Set From Same Side
Cuts installation costs in half.

High Clinching Action
Pulls parts together with up to 600 lbs. squeeze. Eliminates need to clamp.

Wide Grip Range
Simplifies inventory, purchasing, inspection. Same length "POP" Rivet holds tight through thick or thin.

Vibration Proof
"POP" Rivets cannot back out or become loose. Ensures tight assembly for years of use.

Low Head Profile
Where space is important, "POP" Rivets' minimum head height eliminates clearance problems and improves appearance.

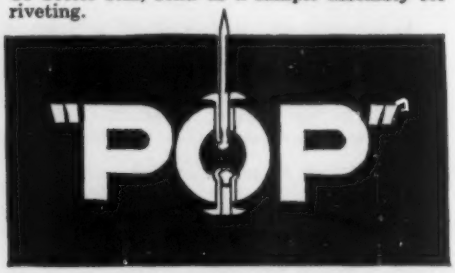
Least Back-Up Space
Strong, high strength "POP" Rivets need only enough back-up space to provide room for set head. Gives more compact design.

- **Cut Assembly Costs**
- **Solve Design Problems**
- **Installed and set from same side**

"POP"® Rivets cut *installed fastener costs*, add design flexibility, and increase assembly convenience because they are inserted and set from the same side. Up to 1200 can be set per hour right on the assembly line — even by an unskilled operator.

"POP" Rivets are precision made, hollow rivets assembled on a solid high tensile mandrel. The setting tool pulls the mandrel head into the rivet from the front side, setting the rivet on the reverse side. Mandrel breaks under tension of up to 1600 lbs. and falls free.

You can cut installed costs, increase assembly convenience, and secure high speed, trouble-free fastening immediately with "POP" Rivets. No need for complicated or extensive re-tooling. Simplify product design, cut handling time. Call or write us today — now — and start cutting your *installed fastener costs* with "POP" Rivets! Or better still, send us a sample assembly for riveting.



"POP" Rivet Division
UNITED SHOE MACHINERY CORPORATION
Shelton, Conn., Regent 5-3391

catalogs and bulletins.....continued

(G-97) Resistance-welding Equipment—Bulletin, 16 pp. Describes line of small parts welding equipment including controls, power supplies, heads, transformers and electrodes. Raytheon Mfg Co, Industrial Apparatus Div, 100 River St, Waltham 54, Mass.

(G-98) Insulation Adhesives—Bulletin, 6 pp. Contains chart of properties, method of application, bonding time, temperature limits, color and coverage of various adhesives for insulating air conditioning ducts and pipes. St Clair Rubber Co, 440 E Jefferson Ave, Detroit 26, Mich.

(G-99) Industrial Locks—Catalog, 60 pp. Describes applications, types and mounting as well as specifications. Description of plating and finishing standards, strikes and escutcheons also included. National Lock Co, 1902 Seventh St, Rockford, Ill.

(G-100) Aluminum Fasteners and Screw Machine Products—Brochure, 8 pp. Contains information on sizes and styles available including parts made from special designs. Aluminum Co of America, 1501 Alcoa Bldg, Pittsburg 19, Pa.

(G-101) Spring Pins—Catalog, 12 pp. Contains engineering information on heavy, medium and light duty models, minimum double shear strength, recommended drilled hole tolerances and list prices. CEM Co, 24 School St, Danielson, Conn.

(G-102) Hard-alloy Fasteners—Brochure, 4 pp. Reports on the materials, dimensions, minimum tolerances and installation procedure for this line. Allmetal Screw Products Co., Inc, 821 Stewart Ave, Garden City, NY.

(G-103) Rivets—Bulletin, 4 pp. Illustrated description of types, materials, sizes and operation. Includes selection and application charts, tools and drawings. "POP" Rivet Div, United Shoe Machinery Corp, Shelton, Conn.

(G-104) Pins—Bulletin, 8 pp. Contains specifications and engineering data covering various diameters and grip lengths available; illustrates typical applications for single acting self-locking quick-release pins. Aviation Developments Inc, 210 S Victory Blvd, Burbank, Calif.

(G-105) Nuts—Catalog, 19 pp. Describes construction features, limensions and layouts for various types. Fastex Div, Illinois Tool Works, 195 Algonquin Rd, Des Plaines, Ill.

(G-106) Rivets—Catalog, 31 pp. Used for solution of blind-side clearance problems in aircraft and missiles. Contains typical diameters, applications, test and ordering information. Has sheer strength up to 95,000 psi. Deutsch Fastener Corp, PO Box 61072, Los Angeles 61, Calif.

(G-107) Locknuts—Brochure, 8 pp. Self-locking nut made with spring steel insert in sizes from $\frac{1}{8}$ in. through 4 in. thread. Security Locknut Corp, 1800 N 15th Ave, Melrose Park, Ill.

GRIPCO FASTENERS

GRIPCO FASTENERS

★ Improve Product Durability
★ Available From Stock
★ Lower Initial Cost
★ Reduce Assembly Time
★ Resist Stress and Vibration

The Grip Nut Company, originator of the Gripco locking feature, has had unsurpassed experience in the most exacting of all fields for the use of locking type nuts—railroad transportation. Grip Nut has been supplying lock nuts to American railroads and railroad car builders for over 50 years. All other major industries are represented among the regular users of Gripco Fasteners. Various types of working conditions and many difficult production problems have been met and overcome by Gripco Fasteners.

All items listed are stock items, available for immediate delivery. The Grip Nut Co. will welcome an opportunity to work with product designers and production engineers on any detail of the application of Gripco Fasteners. Broadly experienced sales and engineering personnel are located in most sections of the country, ready to assist in the solution of your fastener problems.

GRIP NUT COMPANY

Write or phone today for Gripco Fasteners Catalog, Price Lists and samples.

ESTABLISHED 1904

OFFICES AND FACTORY: 102 Maple Street, South Whitley, Indiana • PHONE: South Whitley 112 • REPRESENTATIVES LOCATED IN: Cleveland, Ohio; Los Angeles and San Francisco, Calif.; Detroit, Mich.; Chattam, N. J.; Portland, Ore.; Chicago, Ill.; Salt Lake City, Utah; Milwaukee, Wis.; Louisville, Ky.; and Davenport, Iowa; St. Louis, Mo.

CENTER LOCK NUT

All metal, steel, brass or aluminum. Same dimensions as standard nuts (both full and jam). Eliminates necessity for lock washers and other locking devices. Locks on the bolt-seating nut necessary for locking action. Low in cost—sizes #6 thru 1½", fine and coarse thread.

GRIPCO HI-NUTS

For applications requiring greater thread strength, such as U bolts for trucks, trailers, buses and cars. Sizes—⅝" thru 1¼" fine thread only.

STANDARD HEXAGON NUTS (Steel or Brass)

Finished and Heavy Series, full and jam dimensions. Finished and Heavy Series, single chamfer washer face ¼" thru 1½" Finished Series double chamfer ¼" thru ⅝" (full size only). Brass Hexagon Nuts, finished and heavy series (full and jam) ¼" thru ⅝".

GRIPCO PILOT WELD NUTS

Circular locating collar for easy, quick positioning. 3 weld projections for a firm, nonrocking electrical connection. Furnished with or without GRIPCO locking feature. Sizes—#6 thru ⅝" fine and coarse thread. 2 collar thicknesses for different gauge metals.

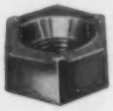
CENTER LOCK NUT

Double Chamfered, with locking feature in center, can be applied from either end. Can be automatically fed. Speeds application. Will lock wherever it is turned on a bolt. Available in steel. Brass and aluminum on special order. Offered in finished series, double chamfered from #8 through ⅜" in fine or coarse threads. Heavy series made to special order only.

GRIPCO CLINCH NUTS

Hexagon Collar fits into hex hole preventing nut from turning. One pilot height for each size which clinches into normal gauge metal. Ideal for blind applications. Furnished with or without GRIPCO locking feature. Sizes—#4 thru ⅜", fine and coarse thread.

All listed cataloged items are available from stock for immediate delivery.



GRIPCO Counter Sunk Weld Nuts

Bottom of nut has countersink to eliminate fouling of threads by molten particles during welding—no retapping. Furnished with or without GRIPCO locking feature. 3 weld projections for a firm, nonrocking electrical connection. Sizes—#8 thru ⅝" with fine and coarse threads.

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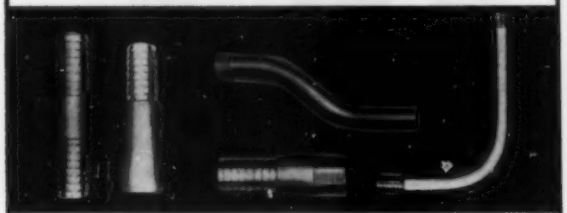
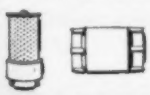
CONNECTORS • COUPLINGS • ADAPTERS by CAMPBELL



Threaded or serrated . . . standard or double swaged stainless steel . . . copper . . . brass . . . aluminum . . . steel . . . or other alloys . . .

MANUFACTURERS OF FOOT VALVES AND CHECK VALVES



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CAMPBELL MANUFACTURING COMPANY, INC., BOYERTOWN, PA.

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New . . . Revolutionary

BLIND FASTENER with THREADS

MOLLY JACK NUT

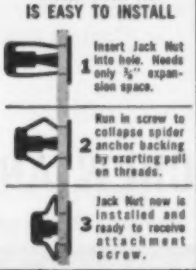
ACTUAL SIZE OF SMALLEST JACK NUT

The ONLY Blind Fastener Which Grips ANY Material From 0" to 3/16" Thick

Ask Your Industrial Distributor or Write for FREE Brochure

MOLLY CORP.
230 N. 5th St., Reading, Pa.

MOLLY JACK NUT IS EASY TO INSTALL



1 Insert Jack Nut into hole. Needs only ⅛" expansion space.

2 Run in screw to collapse spider anchor backing by exerting pull on threads.

3 Jack Nut now is installed and ready to receive attachment screw.

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One order, one source
. . . every fastener need!

Some things need to be different...

Sound connections are of utmost importance to every project, especially today as requirements become increasingly critical. Many times the unusual is the economical answer. Making the unusual is an important part of our service. And because of our complete facilities and design engineering experience, we usually come up with complete answers.

For operating dependability and efficiency, we might suggest a slight modification of design or material of the part in use. Then again, one of our many standards may better suit your needs. Either way, if you have a particular connection problem—one requiring a low-cost solution, let us see what we can do to help. The services of our specialists are readily available through your Screw and Bolt representative. Contact him today or write us direct. Others do.

VMA 6732

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AMERICA'S MOST COMPLETE LINE OF INDUSTRIAL FASTENERS

stitching together a giant radome

Radome designed and built by Long Sault Woodcraft Limited, St. Andrews East, Quebec, for the United States Air Force RADC.

Looking upward from the inside of the world's largest stressed skin sandwich radome built of translucent fiberglass panels, securely joined by hundreds of DUAL-LOCK fasteners.

Radar antennae along the upper perimeter of North America's defense system are enclosed by protective domes which stop ice, snow, and gales up to 150 mph.

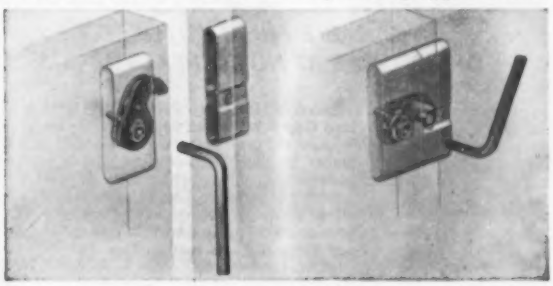
This precisely engineered pattern of fiberglass panels is erected quickly and surely, under the most adverse field conditions, using recessed Simmons DUAL-LOCK fasteners.

DUAL-LOCK is ideally adapted to panel fastening for military shelters, demountable shipping containers, aircraft cowlings and guided missiles.

Features:

- High load characteristics. The standard No. 1 DUAL-LOCK withstands 2500-lb. tension, and with modifications, tension loads of 7000 lbs. and over.
- Double-acting take-up provides great closing pressure, with minimum pressure on operating tool.
- Positive-locking. Trigger action insures fully open and fully closed positions.
- Vibration-proof and impact-proof. Will not accidentally unlock or loosen.

Write for catalog #1257. Complete specifications, drawings, details of DUAL-LOCK and other Simmons Fasteners with unlimited money-saving applications.



SIMMONS FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

See our catalog in Sweet's Product Design File

QUICK-LOCK • SPRING-LOCK • DUAL-LOCK • ROTO-LOCK • LINK-LOCK • HINGE-LOCK

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Another New Fastener Idea From Parker-Kalon

The New PARKER-KALON **W-POINT** Socket Set Screw

PATENT PENDING

Now you can get the highest degree of holding power ever attained!

30% more back-out torque 50% more resistance to vibration 50% more resistance to rotary slippage

Like many important advances in technology, the Parker-Kalon W-Point concept is simple and straightforward. In use, its superior performance and holding power will be demonstrated to your own satisfaction. Available from P-K distributors at no increase in cost.

A COMPLETE LINE OF SOCKET SCREWS TO MEET EVERY REQUIREMENT!

SOCKET HEAD CAP SCREWS

Heads are of uniform diameter. Threads Class 3A tolerance. Available in standard sizes from #0 to 1½" diameter in alloy steel and from #0 to ¾" diameter in stainless steel. Also available in new Pre-Lode style (see below).

SOCKET SET SCREWS

Precision Class 3A threads, standard in Cup Point from #0 to 1" and in Flat, Oval, Cone and Half-Dog Points from #4 to ¾". Cup Point also available in stainless steel.

SHOULDER SCREWS

Threads Class 3A tolerance. Heads are concentric with body for uniform, accurate assembly. Available in standard sizes from ¼" to ¾" diameter.

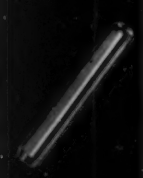
FLAT HEAD SOCKET CAP SCREWS

Seats flush when countersunk. Heads have uniform 82° angle. Threads Class 3A tolerance. Special alloy steel, heat treated. Available in standard sizes from #4 to ¾".

BUTTON HEAD SOCKET CAP SCREWS

Heat treated alloy steel. Accurate hex sockets make for non-slip driving, prevent mutilated heads. Threads Class 3A tolerance. Standard sizes from #4 to ⅜".

DOWEL PINS



Available in .0002" standard and .001" oversize for repairs. Precision ground. Dimensionally accurate.

HEX KEYS

Made of special analysis alloy steel, scientifically engineered. Heat treated for optimum physical characteristics. Made to close tolerances.

SOCKET PIPE PLUGS

Standard sizes 1/16 to 1¼ available in either Dryseal (N. P. T. F.) or Standard (A. N. P. T.)

the new **P-K® PRE-LODE**

1960 Series

Socket Head Cap Screw

AVAILABLE FROM AUTHORIZED P-K DISTRIBUTORS AT NO INCREASE IN COST!

Now . . . Parker-Kalon's new PRE-LODE Socket Head Cap Screw gives you *greater bearing surface under the head than ever before!* Takes higher torque . . . pre-loading . . . for maximum holding power without danger of marring or indenting softer materials. Greater load carrying capacity—better functioning in holes having a greater body clearance. In many cases, the socket has been enlarged to allow more wrenching area. Standard sizes from ¼" to 1" are *Size-Marked* for easy identification.

PARKER-KALON

FASTENERS

PARKER-KALON, a division of *General American Transportation Corporation, Clifton, New Jersey. Offices and Warehouses in Chicago and Los Angeles.*

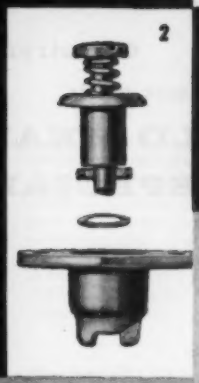
KEEP AMERICAN INDUSTRY AT WORK . . . BUY P-K . . . MADE IN U.S.A.

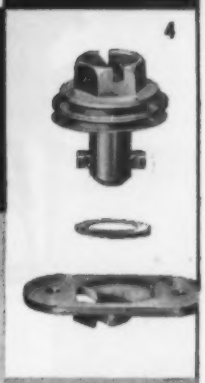
specialists in fasteners for industry

speed · versatility · positive performance

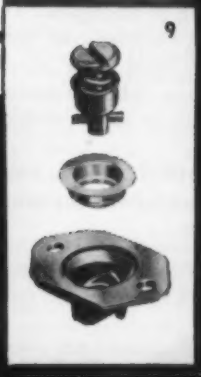
Outstanding creative engineering at Camloc has produced a variety of fastening devices. For access panels, doors, other closures, for simplified replacement of components and sub-assemblies. There are other fastening devices, designed for a variety of specialized applications, all of them retaining the three important features that characterize all Camloc products . . . speed, versatility and positive performance.

CAMLOC





1. SF fastener for thin materials
2. 2600 Series Quarter-Turn
3. Miniature Toggle Tension Latch
4. 91F Heavy Duty Quarter-Turn
5. Electronic Chassis Latch
6. Push Button Latch
7. 28F Series Quarter-Turn
8. 7C Harness Clamp
9. 4002 Series Quarter-Turn
10. SPF (Stressed Panel Fastener)



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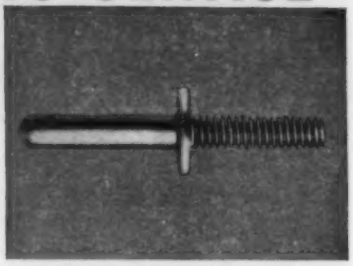
FASTENING AND JOINING

National SPECIAL PRODUCTS SERVICE

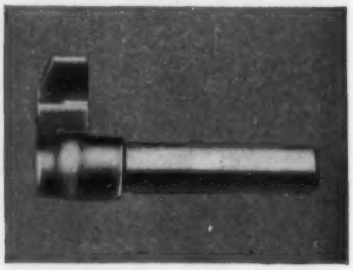
Precision parts with closely held tolerances and excellent surface finish, like this, can also be cold headed more economically and quickly.



Small parts like this can be produced, by cold heading, in huge hourly volume and at low unit cost.

Get strength at low cost with

COLD HEADED SPECIALS!



Intricate formations, like this, difficult or too costly by other methods, become routine production in the cold heading process.

You can make remarkable savings and get better parts in many cases by letting us duplicate and improve on parts you previously have had machined, cast or forged. It's possible with National cold heading!

What's more, we can quickly tell you whether cold heading would be an advantage for new designs.

Here's how National cold heading reduces unit costs . . . gives you better parts!

You save on production costs, because cold heading is fast . . . production rates of 50 to 300 pieces per minute are common. You don't pay for waste. Scrap loss in cold heading is negligible. You save on cost of extra operations, because cold heading eliminates them entirely or reduces their number. And most secondary operations, when required, can be performed automatically in mass production.

Cold heading assures strong, sound parts with good finish and excellent resistance to fatigue, shear and impact!

You're sure of strong parts because cold working *increases* the strength of steels and nonferrous metals. Subsequent heat-treatment or hardening can produce practically any degree of physical properties you desire.

You're sure of sound, clean parts because any defects, such as seams and inclusions, will open up in cold working . . . resulting in *automatic rejection.*

You're sure of superior fatigue, shear and impact resistance because cold heading produces continuous, unbroken flow lines in the grain of the metal . . . impossible to obtain by any other method.

You're sure of good surface finish, with a maximum of 50 micro-inch on cold headed surfaces. Cold heading won't cut or break the specially prepared, smooth, compressed and toughened surface of the rod.

National's cold heading specialists have many years of design and production experience. Combined with National's tremendous facilities for cold heading and secondary operations, this assures you of outstanding work and help in design and production of your parts.

Write for National's booklet, *Special Products.* To learn more about what National cold heading can do for you, send us your specifications or call in your nearest National representative.

National PRODUCTS

THE NATIONAL SCREW & MFG. CO. • CLEVELAND 4, OHIO

California Division, The National Screw & Mfg. Company · 3423 So. Garfield Ave., Los Angeles 22, Cal.

Sales Representatives in: Boston; Dallas; Denver; Greensboro, North Carolina; Kansas City, Missouri; Lansing, Michigan; Rochester, New York; Memphis; Milwaukee; St. Louis; St. Paul; Montgomery, Pennsylvania; San Francisco; Portland, Oregon; Indianapolis.

FASTENING SPECIALTIES BY *National*

Get more dependable holding power for better product assembly with these National SPECIALTY FASTENERS!

Lok-Thred® Bolts, Studs, Screws—Seal and lock against involuntary loosening... Lok-Thred re-forms the metal of the receiving thread under high compressive stresses into intimate contact with itself, eliminating all voids. Yet, it's fully re-usable. Requires no selective fits. Can be used with ordinary tools. Available in all sizes of bolts, studs, screws... No. 6 or larger.

Spin-Lock® Fasteners—Give you strength at low cost, with self-locking, ratchet-tooth action . . . Spin-Lock machine and tapping screws have angled teeth to permit fast, easy tightening. They require about 20% greater torque to loosen. Available in pan, truss, flat and hex heads; slotted or Phillips recessed heads; No. 4 to $\frac{3}{8}$" diameters, lengths from twice diameter and up.

Thread Cutting Screws—For joining metals or plastics without tapping... Use wherever it is desirable to remove rather than displace thread material. Four types: 1, 23, 25, and F cover most applications. Phillips or slotted heads, all styles, all sizes. Also type A and B tapping screws for fastening light sheet steel or light gauges of other metals.

Lock Nuts—Three types, to meet every requirement... 1. *Huglock*, for locking without seating and under adverse conditions. 2. *Marsden*, free-running until seated . . . for minimum-cost locking. 3. *Drake*, a two-piece design for use under severe stresses, shock, vibration. All types are all-metal, fully re-usable without loss of positive locking action.

Welding Fasteners and Weldnuts—Provide trouble-free assembly of fabricated metal parts... Use National welding fasteners when primary fasteners must be cleanly welded into exact position. National's complete line of projection welding screws and nuts is available in stock sizes, for optimum welds in materials .030 to $\frac{1}{4}$" thick. We will develop special designs for you.

Flex-Head® Locking Screws—Self-locking, highly resistant to fatigue, shock, impact... Tight locking results from flexing of the head and axial spring tension produced when fully torqued against a rigid seat. Flex-Head screws are identical in dimension, and interchangeable with standard machine screws. Made of 1022 steel and heat-treated for top strength.

Tuff-Tite® Cushioned Fasteners—Seal openings, eliminate vibration noises, absorb shock... Pre-assembled neoprene washers also prevent finish marring! Available as tapping screws, thread cutting screws, machine screws, roofing bolts, stove bolts, or wood screws; with Phillips or slotted heads; pan, round, truss or hex head styles.

Place® Bolts—Self-locking...resist impact, shock and fatigue failure by controlled spring action of reinforced, diaphragm head... Place bolts resist involuntary loosening when rigidly seated. Typical uses: connecting rod bolts, main bearing cap screws, flywheel bolts. Available in high carbon or alloy steel, in a wide range of sizes.

Save yourself time and trouble in searching for the right fastener. Make National your *one source* for standards, specialties and special designs. Our standard line includes all types and sizes . . . nuts, cap and set screws, machine bolts, carriage, step and elevator bolts, plow bolts; Phillips recessed head, or slotted, Sems, machine screws, wood screws; stove bolts, pipe plugs, cotter pins and rivets.

National can supply any nonstandard fastener, or design and produce specials for you. Write for National's *Special Products* booklet, or for information on the fastening specialty that interests you.

THE NATIONAL SCREW & MFG. CO. • CLEVELAND 4, OHIO

National PRODUCTS

STRONGER IN TENSION, TORSION AND SHEAR

SIMPLE TO INSTALL

REQUIRES NO SPECIAL TOOLS

CAN'T BACK-OUT OR FRET

LOK-THRED®

FOR STRONGER, SELF-LOCKING FASTENING

ECONOMICAL INSTALLED COST

GOOD SEALING QUALITIES

HIGH FATIGUE CAPACITY

WORKS WELL IN ALL METALS

REUSEABLE AFTER REMOVAL

LOK-THRED is ideal wherever dependable, self-locking, or self-sealing fasteners are required to meet conditions of severe vibration, tension, torsion or thermal loading.

LOK-THRED has proved its superiority in Aircraft engines, missiles. Automotive engines, pumps, instruments, transmissions, connecting rods, rocker arms. Heavy agricultural, earthmoving and construction equipment. Diesel engines. Outboard motors. Household equipment. Electric motors and equipment. Building hardware. Industrial machinery.

Technical details available on request.

LOCK THREAD CORPORATION
2832 East Grand Blvd., Detroit, Mich., TRinity 2-1400

LOCK THREAD LICENSEES INCLUDE

AMERICAN STANDARD PRODUCTS, Inc.
3030 Main St.
Hartford, Conn.

FEMCO MANUFACTURING CO.
22845 Hoover Road
Detroit 5, Mich.

FERRY CAP & SET SCREW COMPANY
2151 Scranton Road
Cleveland 13, Ohio

THE LAMSON & SESSIONS CO.
5000 Tiedeman Road
Cleveland 9, Ohio

MAYNARD MANUFACTURING COMPANY
22755 Shakespeare
E. Detroit, Mich.

THE NATIONAL SCREW & MANFG. CO.
2440 E. 75th St.
Cleveland 4, Ohio

CLAUDE SINTZ, INC.
1928 Stanley
Detroit 8, Mich.

STANDARD PRESSED STEEL COMPANY
Aircraft/Missile Division
Jenkintown, Pa—Santa Ana, Cal.

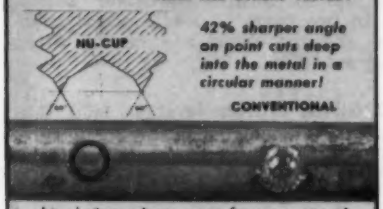
STANDARD SCREW COMPANY
2701 Washington Blvd.
Bellwood, Ill.

UNIVERSAL DIESEL PRODUCTS, Inc.
Sturgis, Michigan

check these cost-cutting NEW IDEAS from SETKO

then check the coupon below for full information and free test samples

IDEA #1 "NU-CUP® POINT GRIPS THINWALL TUBING BETTER THAN ALL OTHERS TESTED!"



42% sharper angle on point cuts deep into the metal in a circular manner!

An independent manufacturer tested all types of points to find the one that would hold best . . . and perform most dependably. He chose NU-CUP. Could you use this idea? Check No. 1. (Name of Mfr. on request.)

Set Screw & Mfg. Co.

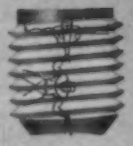
IDEA #2 THIS COST-CUTTER TAKES 50% MORE TORQUE BECAUSE OF SLABBED HEAD CONSTRUCTION!

Costs less than comparable hexagon head set screws.

If you are having trouble with stripped heads or insufficient holding power, chances are the Setko Slabbed Head Set Screws are just the idea you need . . . Available in all points and metals. Check No. 2!

Set Screw & Mfg. Co.

IDEA #3 IS VIBRATION CAUSING LOOSE SET SCREWS ON YOUR PRODUCTS? . . . ELIMINATE THIS PROBLEM WITH ZIP-GRIP®!



Slight variation of thread causes locking action on mating surface!

Proven as an outstanding principle in many products, Zip-Grip has found particular acceptance wherever the stress of movement or vibration occur. Makes an outstanding adjusting screw . . . Can be reapplied many times . . . Got an idea? Check No. 3.

Set Screw & Mfg. Co.

IDEA #4 TINY SCREWS DO BIG HOLDING JOB . . . THEY'RE CALLED "MINI-MITE"

You'll find them perfectly-produced counterparts to their big brothers!

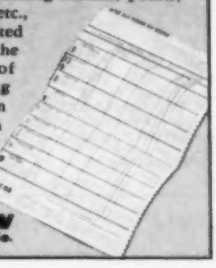
If miniaturization is one of the fields that you're interested in, then you'll see many good ideas in the perfectly-produced, money saving selection of Mini-Mites . . . Why pay for Specials when these can keep your costs at a minimum . . . Get the idea? Check No. 4.

Set Screw & Mfg. Co.

IDEA #5 NEW SELF-LOCKING SET SCREW SELECTOR CHART LISTS OVER 1,001 COMBINATIONS.

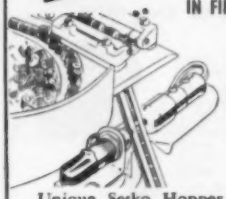
Helps you determine available combinations best for your particular application!

Here is another Setko first . . . A complete listing of locking actions, points, metals, drives, etc., including suggested applications of the complete line of Setko self-locking screws . . . It's jam packed with ideas for you! Check No. 5.



Set Screw & Mfg. Co.

IDEA #6 "SETKO HOPPER FEEDER SAVED US $42,000 IN FIRST YEAR."



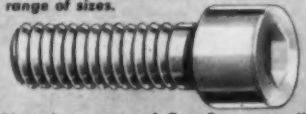
Here's the first truly Automated method of hopper feeding Headless Set Screws.

Unique Setko Hopper Feeder design orients headless Set Screws then feeds them to a driving device . . . Savings like the one shown above are but one of the advantages (name of mfr. on request) . . . Product quality is consistent, etc. This cost-cutting idea is one you can't miss! Check No. 6.

Set Screw & Mfg. Co.

IDEA #7 NEW LINE OF COLD FORGED "PERFECT HOLE" CAP SCREWS PRECISION MANUFACTURED!

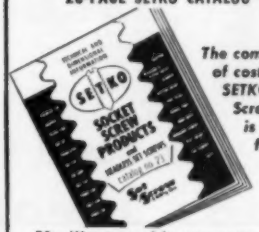
Specially-designed machinery produces uniformly perfect cap screws in wide range of sizes.



If you're a user of Cap Screws you'll want to examine these yourself . . . We know you'll get our idea of trying to produce a perfect product consistently . . . We're sure you'll appreciate their performance once you've tried them . . . Would you like test samples? We'll be glad to send them! Check No. 7 and indicate sizes, etc.

Set Screw & Mfg. Co.

IDEA #8 THERE'S A BARREL-FULL OF IDEAS IN THE NEW 28-PAGE SETKO CATALOG #23.



The complete line of cost-cutting SETKO Socket Screw Products is at your fingertips.

You'll want this compact catalog for your personal use . . . And you'll particularly like the easy to read manner in which it has been prepared. Want a copy? Check No. 8.

Set Screw & Mfg. Co.

679

Set Screw & Mfg. Co.

753 MAIN STREET, BARTLETT, ILLINOIS

Please send me Idea information on items checked below. (If FREE samples are wanted of any of these products, send your specifications).

- ☐ 1. Nu-Cup
- ☐ 2. Slabbed Head
- ☐ 3. Zip-Grip
- ☐ 4. Mini-Mite
- ☐ 5. Self-Locking Selector Chart
- ☐ 6. Hopper Feeder
- ☐ 7. Cap Screw
- ☐ 8. Catalog

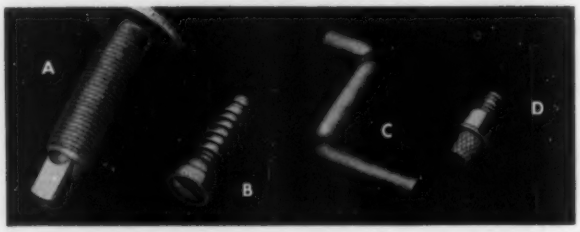
NAME _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

R B&W FASTENERS SOLVE SPECIAL PROBLEMS

Cold heading creates quality parts the low cost way



No value analysis of product components is really complete without exploring what cold heading machines can do to cut costs. Some examples:

ELIMINATE EXTRA OPERATIONS. Leveling screw, formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head during assembly.

FASTER THAN FORGING. Shifter lever is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

METAL FLOWS TO SHAPE—NO WASTE. No longer cut on screw machine, insert screw for plastic parts cost 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

Metal forced to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

TENSILOCK* SCREWS AND NUTS

"Tensilock," the high tension locking fastener, bites into seating surface with hardened ratchet teeth . . . holds tight despite severe vibration or cyclic heating and cooling. High residual tension combines with tooth grip and spring action of flexible flange to make required loosening torque as much as 40% more than tightening torque. Wide range of sizes and styles. *TM

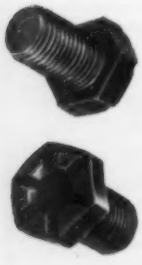
PIGMENTED NYLON OR DELRIN® NUTS

RB&W open-end acorn nuts of pigmented nylon or Delrin feature low cost, reusability, corrosion resistance, and constant prevailing torque. Metallic gray in color, but can also be supplied in other colors. Available in 10-24 and 10-32 sizes, they develop a clamping force of up to 500 pounds. Other sizes available upon sufficient demand.

® Dupont Trade Mark

SPIN-LOCK SCREWS

These RB&W screws offer in flat head and filister head design a locking action similar to that of RB&W's Tensilock® screws. They have ratchet-like teeth that bite into the bearing surface when tightened and resist loosening from vibration or temperature cycling. Reusable. Wide range of sizes.



PLACE BOLTS

Head with circular indentation, six slots and recessed bearing surface provides "diaphragm" which flexes when bolt is tightened and helps retain tension in joint should bolt return to its original length.

STAKED NUTS

Staked on opposite sides for positive grip and spring tension locking effect. Available in regular double chamfered style or acorn style (illustrated), in aluminum, steel, silicon bronze.

WELDING FASTENERS

RB&W standard welding bolts have welding projections on top of or underneath the head. Sizes from No. 6 through ½ inch. Welding Nuts can also be supplied.

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. **Additional sales offices at:** Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

RB&W fasteners—Strong Point of any assembly

depend on...

NATIONAL LOCK

for all your appliance hardware and fastener requirements

RANGE HARDWARE • HANDLES
REFRIGERATOR HARDWARE
BUTTS • CONTINUOUS HINGES
CABINET HARDWARE • CATCHES
LATCHES • CASTERS • PLASTICS
SHELF SUPPORTS • SCREWS
BOLTS • STAMPINGS
SPECIAL-PURPOSE FASTENERS

Simplified purchasing and inventory control . . . dependable delivery . . . all are a part of the service when you order your quality hardware ALL FROM 1 SOURCE . . . from NATIONAL LOCK COMPANY. National Lock standard and custom-built products are quality controlled and competitively priced. • Send us your "specs", you'll readily see how our extensive engineering and manufacturing facilities can save time and money right down your production line. You can depend on it.

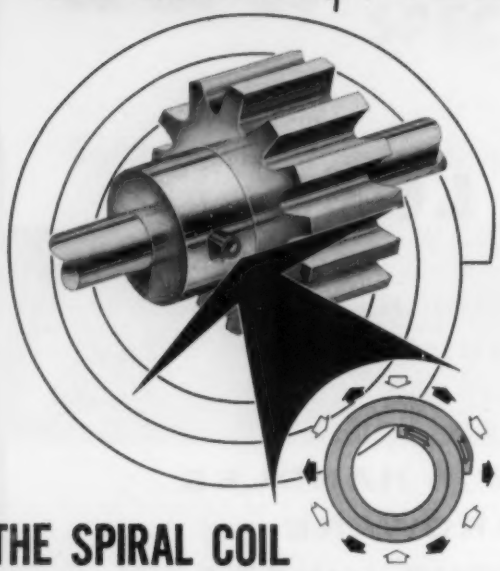
QUALITY HARDWARE . . . ALL FROM 1 SOURCE

NATIONAL LOCK COMPANY

Rockford, Illinois • Industrial Hardware Division

WRITE 411 ON READER SERVICE CARD 411

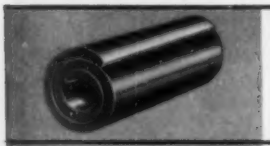
SPIROL the true spring PIN



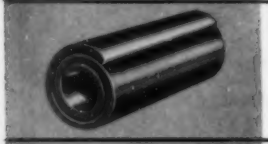
THE SPIRAL COIL makes SPIROL a true spring PIN

SPIROL PIN is a spirally coiled metal strip that acts like a true spring. When the pin is compressed into a hole, the radial tension is distributed uniformly throughout the spiral coils. There is no concentration of stress. This real coil-spring action permits wider plus-*and*-*minus* hole tolerances . . . eliminates precision reaming. Available from stock in nickel stainless steel and other low cost, non-heat-treated metals; also carbon steel and chrome stainless steel hardened and tempered. SPIROL's greater resilience increases shear strength, shock and vibration resistance.

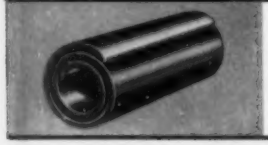
SPIROL offers the widest range of flexibility, tension, and strength . . .



HEAVY DUTY
For applications where shear and shock loads are extremely severe, Spirol pin's spring action withstands high stress.



MEDIUM DUTY
Flexibility enables medium duty pins to absorb severe vibration. Have adequate shear strength for majority of applications.



LIGHT DUTY
Recommended for use in soft and brittle materials where the allowable bearing loads are low.

SPIROL is the only Spring Pin in MINIATURE DIAMETERS

1/32" — .039" — 3/64" — .052"

FREE! *Write for literature on Spirol Pins.*

C. E. M. COMPANY • 136 SCHOOL ST. • DANIELSON, CONN.

MOORE . . . your dependable source for DEPENDABLE SET SCREWS

- *standards or specials*
- *one or a million*
- *precision made*
- *quality controlled*
- *priced right*

Something as small as a set screw shouldn't give you any trouble . . . and it won't, either, when you specify *Moore Set Screws*. Rigid quality control guarantees conformity and uniformity. *Your* production lines run smoothly and *your* quality control is simplified.

Engineering Service — on new developments, or when you have a problem, let us provide the answers.

Send for detailed price catalog.

	Headless Slotted	Square Head	Socket Head
Size (dia.)	#0 to ¼"	#6 to ⅜"	#4 to ⅜"
Lengths	1/16 to 3"	3/16 to 2½"	⅛ to 1"
Points	cup, oval, round, flat, cone, dog		
Materials	steel, brass, bronze, stainless, aluminum, alloy steel, monel		
Special Heads — milled, slabbed, double slot, knurled. Miniature Headless—#0, #1, #2, #3 sizes in a wide selection of metals, finishes, lengths and points.			

MOORE SET SCREWS

George W. Moore, Inc.
since 1880
92 Beaver St., Waltham 54, Mass.

WRITE 651 ON READER SERVICE CARD

Why is it that the really busiest men always seem to have the most time to read?

Not long ago, we talked with the president of a huge international organization. He confessed to being an ardent reader of a certain McGraw-Hill magazine.

"When in the world do you ever find time to read it?" we asked him. "Why, it's right here in my briefcase," he said.

This shouldn't startle you. Important men make time to read their own McGraw-Hill publication. They know success and specialized knowledge are bedfellows.

How well are you reading this, your own magazine? Are you a "skimmer" or a bonafide reader? How about others in your department? When you're finished reading, pass your issue along, with this particular page opened . . .

Men who read more . . . earn more!

catalogs and bulletins.....continued

(G-108) **Fasteners**—Brochure, 24 pp. Describes types and applications; gives engineering information and test results; offers technical assistance and samples. Parker-Kalon Div, General American Transportation Corp, 1 Peekay Drive, Clifton, NJ.

(G-109) **Toggle Clamps**—Catalog, 43 pp. Illustrates models and basic styles of quick-action toggle clamps. Includes small scale dimenisonal drawings of the side and top clamp views; also includes accessories and price list. Detroit Stamping Co, 350 Midland Ave, Detroit 3, Mich.

(G-110) **Concealed Hinges**—Brochure, 15 pp. Shows various sizes for door or cabinet installations. Selection chart, door clearance drawings and information on exposed type. Soss Mfg Co, PO Box 38, Harper Station, Detroit 13, Mich.

(G-111) **Fasteners**—Catalog, 46 pp. Gives dimensions, materials and standards for cold headed fasteners and parts, standard machine screws, rivets, studs, and special fasteners. Harvey Hubbell Inc, Bridgeport 2, Conn.

(G-112) **Socket Screw Products**—Brochure, 8 pp. Gives data on socket screws and dimensional standards for the complete line. Brighton Screw & Mfg Co, Reading Rd, Cincinnati 2, Ohio.

(G-113) **Rubber-to-Metal Bonded Parts**—Brochure, 8 pp. Covers bonding problems and specific products such as mounts, rolls, valve seats, and others. Acushnet Process Co, Belleville Ave, PO Box 916, New Bedford, Mass.

(G-114) **Socket Screws**—Catalog, 23 pp. Diameters, thread sizes, packaging information and net price schedule of pipe plugs, cap screws, hex keys and all standard socket screws. Safety Socket Screw Co, 6501 N Avondale Ave, Chicago 31, Ill.

(G-115) **Screws and Crating Bolts**—Brochure, 4 pp. Describes design and various applications; includes technical engineering information, illustrations, types and sizes available. Pheoll Mfg Co, Inc, 5700 W Roosevelt Road, Chicago 50, Ill.

(G-116) **Fastening Devices**—Brochure, 4 pp. Gives description of standard, high temperature and titanium alloy fasteners for the aircraft industry. Also covers line of screws, rivets, turnbuckles, and others. Voi-Shan Mfg Co, Div of Voi-Shan Industries, Inc, 8463 Higuera St, Culver City, Calif.

(G-117) **Welded and Weldless Chain**—Catalog, 4 pp. Describes and illustrates most popular welded and weldless items and assemblies; includes working load limits. Campbell Chain Co, York, Pa.

(G-118) **Rivets and Setting Machines**—Brochure, 16 pp. Contains instruction selection of proper rivet size, capacities, machine weights, power and specifications. The Milford Rivet & Machine Co, 857 Bridgeport Ave, Milford, Conn.

How to LOCK-UNLOCK-RELOCK the same screw in Steel without Lock Wiring or Lock Nuts

The ***Heli-Coil***® Screw-Lock Insert* is the only insert made of wire which has an exclusive resilient internal locking feature that permits repeated assembly and disassembly of the same screw This patented insert insures minimum screw wear and maximum locking torque value—it meets military specs for locking torque and vibration through 550°F.

Made of stainless steel wire, the Screw-Lock Insert protects tapped threads permanently and is not affected by acids, solvents or high temperatures You can eliminate lock nuts, lock wiring and other clumsy external locking devices The locking coil will never relax its grip even in tough metals such as meehanite, stellite, titanium, etc. The insert can be used in blind or through-holes and its frictionless stainless steel finish will not gall or seize—even under the most adverse conditions Find out about ***Heli-Coil*** Screw-Lock Inserts and get your free copy of the new data guide to drilling and tapping in *steel* Mail the coupon today.

*Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 609 Shelter Rock Lane, Danbury, Connecticut
Please send my free copy of the new *Heli-Coil* DATA GUIDE TO DRILLING AND TAPPING IN STEEL, and information on *Heli-Coil* Screw-Lock Inserts.

NAME _____ TITLE _____
FIRM _____
ADDRESS _____
CITY _____ ZONE ____ STATE _____ 1810

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

Last year, traffic accidents killed 37,000, injured 1,400,000

. . . and they wasted Five Billion Dollars!

Traffic accidents' human toll is so tragic we sometimes overlook their staggering economic waste. Five Billion Dollars in lost wages, medical expenses, insurance costs and property damage! Your business—every business—shares in this loss. So you have a double interest in helping reduce traffic accidents. And you *can* help! Drive safely and obey the law yourself . . . certainly. But go further. Use your influence to promote safe driving and urge strict law enforcement. To make your efforts more effective, join with others working actively to reduce traffic hazards in your community. *Support your local Safety Council!*

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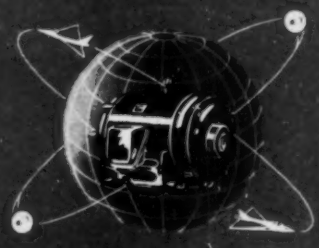
SECTION H

MOTOR, ENGINES AND CONTROLS



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DESIGN ABSTRACTS

38 DIESEL-ENGINE SPECIFICATIONS

Tabulated data on Diesel, dual-fuel, and natural-gas engines made by 38 American diesel-engine builders. Also listed are data on foreign diesel engines that are being actively sold in this country by 15 makers.

"1959 Engine Specifications," Diesel Power, Apr '59, 80 Lincoln Ave, Stamford, Conn.

*

Diesel-fuel Injection

A new injection pump was developed by American Bosch to meet requests for a low cost and more compact pump. Pump employs an annular-fill design which reduces plunger stroke from 6 mm to 3.5 mm.

"New, Simplified Fuel Injection Pump," Diesel Progress, Dec '58, 1701 W. Wisconsin Ave, Wilwaukee, Wisc.

*

High Compression Beneficial

Dynamometer and road tests on a typical British standard production engine and car have been made to determine the effect of varying the compression ratio over a wide load and speed range.

The tests were run on a normally marketed gasoline with relative adjustment to antiknock quality.

A series of cylinder heads, the decks of which were machined appropriately, and pistons with intruders on the crowns enabled the changes in compression ratio to be made from 7 : 1 to 11 : 1.

The data obtained indicate that power and specific fuel consumption at both full and part-load conditions over the speed range are improved as compression ratio is raised. The results of this study have also shown that refinements to the physical characteristics at a given compression ratio resulted in increases in thermal efficiency and power.

Preliminary experiments with sodium-cooled intake and exhaust valves have indicated that the sodium-cooled version of intake valve is the more effective in the reduction of engine octane requirement.

"High Compression—Is It Worth It?" C L Goodacre, B H Watkins, The Associated Ethyl Co, Ltd; SAE paper 66W, SAE, 486 Lexington Ave, New York 17.

*

Engine Wear

Several laboratory test techniques are used for determining wear in both single-cylinder and multi-cylinder engines and are applicable to specific wear problems affecting lubricant development. Piston ring, piston pin, and valve train wear under various operational conditions are discussed in this study.

"Determining Wear in Automotive Engines," R L Pontious, Sinclair Research Laboratories, Inc; Lubrication Engineering, Mar '59, 84 E Randolph St, Chicago 1.

*

Trip-free Controls

Circuit breakers must perform a dual function. They normally serve as a switch to close and open electrical circuits carrying load currents in response to the manipulation of an operating handle or button located either at the breaker or remotely. Their second and more important function, however, is to operate automatically as a safety device to open the electrical circuit in response to overcurrents or faults.

Illustrations

Nine illustrations provide a good understanding of how trip-free action can be accomplished in circuit-breaker mechanisms. In most cases the linkages are represented by single-line digrams. The illustrations of the mechanisms are stripped of all but the bare essentials necessary to convey the trip-free concept. Actual operating mechanisms are often so cluttered with a multiplicity of auxiliary devices, and operator frame and linkage take on such a complex shape to adapt themselves to these auxiliary devices, that identification of the method of trip-free operation is lost.

"Trip-Free Mechanisms," H L Peek, Allis-Chalmers Manufacturing Co; Mechanical Engineering, Mar '59, 29 W 39th St, New York 18.

*

Ac Motors for Adjustable-speed Systems

Describes operating characteristics and control requirements of major methods of obtaining speed control of ac equipment. Included are pole changing techniques, armature resistance control of wound-rotor motors, frequency changing, slip-frequency injection, use of eddy current couplings.

"Take a New Look at Ac Motors for Adjustable-speed Systems," C S Siskind, Purdue University, Control Engineering, 330 W 42nd St, New York 36.

*

Resonant Speeds

All rotating machinery vibrates at resonant speeds. Builders make sure that their turbine speeds are predicted and controlled correctly to minimize vibration. This article explains fundamentals.

A shaft rotating at a resonant speed vibrates at one of its natural frequencies. Rotating-shaft vibration differs from that of a stationary beam. An exciting force working at one of the natural frequencies of the beam makes it vibrate in resonance with rather large amplitudes, even with a small exciting force. A rotating shaft

also has natural frequencies, but it does not need an external exciting force to vibrate.

"What You Should Know About Resonant Speeds," W J Caruso, General Electric Co; Power, Apr '59, 330 W 42nd St, New York 36.

*

Oil Consumption in a Diesel

Using radioactive lubricating oil, correlation between break-in wear and oil consumption was attempted. Consumption was also investigated as a function of engine load, speed, temperature, piston-ring configurations.

"A Study, Using Radioactive Lubricating Oil, of Rate of Oil Consumption in an Operating Diesel Engine," Poberskin, Sunderman, Fithian, Battelle Memorial Institute and Cooper Bessemer Corp; ASME paper 58-A-143, 29 W 39th St, New York 18.

*

Applying Differential Equations to Induction-motor Transients

Equations are provided for solutions on either analog or digital computer that can be used to: 1) generate motor's dynamic and steady-state speed-torque capability curves; 2) predict acceleration time; 3) show response to impact loading; 4) illustrate reaction to line-voltage fluctuations; 5) speed-torque curves for wound-motor action.

"Applying Differential Equations to Induction Motor Transients," H S Nouville, Allis-Chalmers Electrical Review, 1st Quarter, Milwaukee 1.

*

Power System Switchgear

Of the many items making up a power supply system, switchgear is one of the most important and accounts for a large proportion of the total cost. Although no completely new types of switchgear have been successfully introduced for many years there have been continued increases in short-circuit rating, reductions in physical size for given ratings, and a better understanding of the physical nature of the arc. To enable engineers to keep abreast of such developments six advanced lectures by practising switchgear designers, users and research engineers, were recently delivered at the Heriot-Watt College, Edinburgh, and will be summarized in a series of articles dealing with high- and low-voltage oil and air circuit-breakers, selection and arrangement of switchgear and testing.

"Power System Switchgear," A M Cassie, Electrical Research Association; The Electrical Journal, Apr 3, '59, Bouverie House, 154 Fleet St, London EC4, England.

*

Ion Engines

Many factors have stimulated increasing interest in the development of high-performance thrust generators for space vehicles. The ion rocket engine and the plasma rocket are two thrust generators which have become familiar to the engineer and the scientist. These power plants are defined and discussed, with suitable illustrations.

"Ion Rocket Engine Systems," Robert H Boden, North American Aviation, Inc; Aero/Space Engineering, Apr '59, 2 E 64th St, New York 21.

*

3-Phase Motor on Single-phase Supply

Symmetrical component theory is used to express the relationship between the starting performance of a 3-phase induction motor, when connected to a single-phase supply system, and its normal starting performance in terms of two dimensionless parameters.

Performance characteristics applicable to machines of any rating are computed for a range of values of the two parameters, and various conditions for optimum operation are established. Accepted measures of starting quality are discussed critically, and a new criterion relating starting torque and stator copper loss is proposed. It is shown that best starting performance is given by a phase converter which simulates balanced 3-phase conditions in the machine, and experiments on a typical motor indicate that the corresponding run-up performance is likely to be satisfactory.

"The Starting of a 3-Phase Induction Motor Connected to a Single-Phase Supply System," J E Brown and C S Jha, University of Bristol; Institution of Electrical Engineers, Apr '59, Savoy Place, London W.C. 2, England.

*

Speed Control of Ac Motors

A drive using saturable reactors and wound-rotor motor to provide adjustable constant-speed control comparable to dc variable-voltage systems is described. Line contactor connects system to power line. All regulating components are static. Motor currents are controlled in all three phases for motor heating.

"Adjustable Speed Control of AC Motors," L R Foote, General Electric Co; AIEE paper CP 59-84, 33 W 39th St, New York 18, N. Y.

*

Variable-speed Ac Motor

Ac motor using dc excitation to stator and two-phase ac variable voltage to armature (through synchronously revolving brushes) is described. Said to have almost all characteristics of dc motor and power-factor control features of synchronous motor. Also adaptable to single phase and polyphase systems.

"A Novel Type of Smoothly Variable Speed AC Motor Having Widely Adjustable Power Factor Characteristics," P K Charlu, PSG College of Technology (Coimbatore, India), AIEE paper 59-136, 33 W 39th St, New York 18.

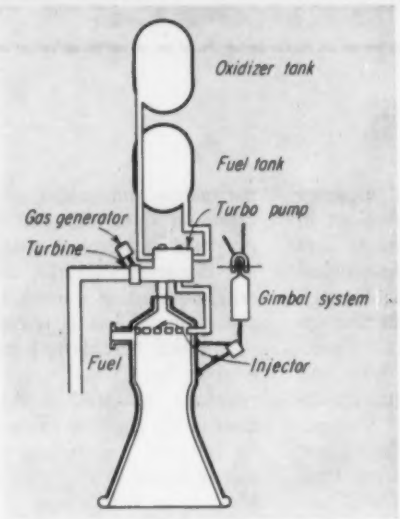


Fig. 1—Schematic of a liquid rocket engine.

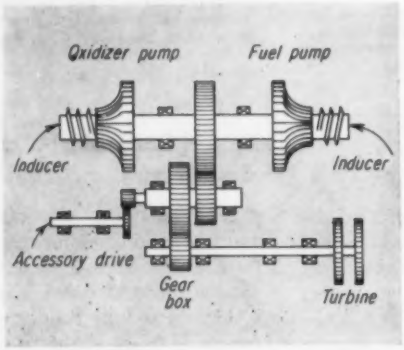


Fig. 2—Schematic of a conventional turbopump.

Conventional Rocket Engine

The engine described develops 150,000 lb of thrust and uses liquid oxygen and kerosene as propellants. Major components, Fig. 1, are: thrust chamber, where propellants are burned and expanded: turbopump package which delivers the propellants to the thrust chamber in the proper amount and at the required pressure; and the gas generator which drives the turbopump.

Thrust chamber is fabricated of formed tubes. Regenerative cooling is obtained by fuel flowing down through alternate tubes and returning via adjacent tubes to the injector. Fuel and oxidizer are introduced into the combustion chamber through the injector.

Turbopump, shown schematically in Fig. 2, is a high speed turbine driven by hot combustion gases obtained from the gas generator. Generator burns the main engine propellant under fuel-rich conditions to give 1200-2000 F turbine working gases. Gear train drives the fuel and oxidizer pumps at lower-than-turbine speed. Pump inlet cavitation limits the pump speed. Spiral inducers increase the permissible cavitation-free pump speed. Increasing propellant tank pressure would allow higher pump speeds but result in excessive tank weights.

Integrated Rocket

From: SAE paper

Engineering emphasis on conventional rocket engine systems shifting away from R&D towards quality and reliability improvements. Advanced design and research engineers are now concentrating on unconventional components and power plants. Integrated engine system approach is one method of improving performance.

GEORGE S. GILL, Supervisor
LEO KUSAK, Senior Research Engineer
Rocketdyne, Inc.

Rocket engine systems are becoming operational and the design and research fields are now concentrating on the more unconventional components and power plants. The term "unconventional" means the mechanical aspects of a chemical rocket engine system, rather than an exotic chemical propellant or a nuclear or other advanced propulsion system. The consideration is towards mechanical and fluid flow improvements.

These improvements, for example, are taking the form of modifying conventional liquid oxygen propellant pump seals to operate with liquid fluorine, or else attempting to maintain satisfactory combustion chamber operation when the design combustion temperature is increased several thousand degrees.

Performance can also be improved by redesign or refinement of the existing engine configuration, especially if performance improvement includes increased reliability, reduce weight or volume, increased thermodynamic efficiency, or reduced fabrication or operating costs.

COMPONENT IMPROVEMENT APPROACH

Combustion efficiency within the thrust chamber and expansion efficiency of the exhaust nozzle are very high in engines of this size—in some instances about 98%. Although an improvement is possible, the amount of effect would not be worthwhile.

A weight saving and increased efficiency is possible for the turbo pump. Elimination of the gearbox would increase system reliability by decreasing pump complexity, and would save weight of the gear box and its lubrication system. The resulting direct drive turbopump, would ne-

Engine System Design

cessitate increasing pump speed and decreasing turbine speed until the two match.

The inducer flow characteristics would have to be improved to allow cavitation-free flow at the higher pump speed, and the turbine blading would require redesign to produce an acceptable turbine efficiency and the lowered turbine speed.

The gas generator may be significantly improved, but the size of this unit and its relationship to the complete system are such that only a small performance increase for the entire engine would result.

INTEGRATED ENGINE SYSTEM APPROACH

An integrated engine is one in which the components are closely related, with certain components performing more than one function. Hence, a light weight, compact, simpler engine results. In such an engine the thrust chamber becomes the focal point of the entire engine design.

If the chamber is envisaged as a mechanism for converting chemical energy into kinetic energy, a wide variation in thrust chamber geometry is possible. Fig. 3 shows the possible variations in geometry.

Conventional thrust chamber is designed for optimum expansion of the exhaust gases to atmospheric pressure at a particular altitude. Below this, exhaust gas expansion results in a thrust loss; above, complete expansion to ambient pressure will not be obtained. With high expansion ratio nozzles, gimballing loads are high and the total heat loads to the coolant may become excessive.

Spherical thrust chamber is a special case of the conventional chamber, with the shape better suited to withstand high chamber pressures but with more difficult fabrication problems.

Throatless thrust chambers are easy to fabricate, and a smaller combustion chamber diameter—due to the diverging exhaust nozzle—results for a given thrust level and chamber pressure. Gas velocities in the combustion chamber, however, are higher and result in a higher average heat transfer rate. Nozzle expansion characteristics are identical to those of a conventional chamber.

Diabatic thrust chamber eliminates both the cylindrical and the convergent portions of the conventional chamber. Configuration is simpler and thus lends itself to various fabrication techniques. At any given thrust level, the weight and size of a diabatic chamber are less than those of a conventional unit. Theoretical performance is less than for a conventional chamber because of the simultaneous combustion and expansion in the diabatic chamber, in contrast to combustion under essentially constant pressure conditions in the conventional chamber.

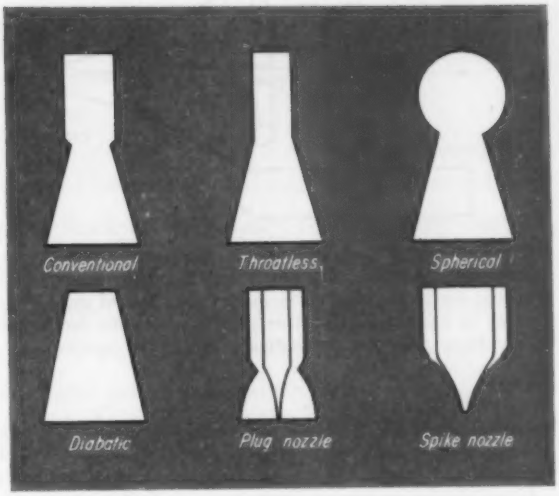


Fig. 3—Possible thrust chamber geometries. Regenerative cooling of these structures is required. It is assumed that the same general cooling techniques can be applied to all.

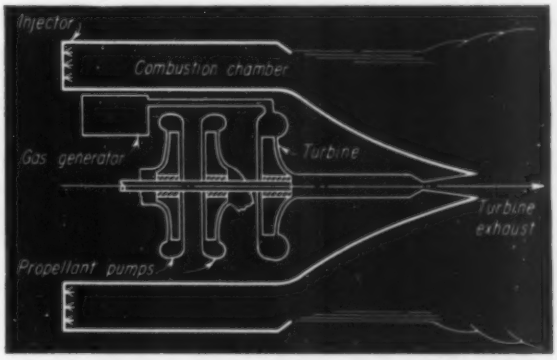


Fig. 4—Spike nozzle thrust chamber. Jet boundary, being unconfined, is able to adjust to changes in ambient pressure by becoming somewhat convergent or divergent as required.

Plug and spike thrust chambers show the greatest promise for the integrated engine system approach. The nozzle portions of these configurations have been used in air-breathing supersonic propulsion systems, and either requires an annular thrust chamber configuration.

The spike nozzle thrust chamber has the desirable characteristic of obtaining near optimum expansion of the combustion gases over a wide altitude range. It eliminates the outer wall of the nozzle portion of the plug nozzle thrust chamber. The remaining center spike (or external plug) is contoured to cancel out the series of weak expansion waves originating at the lip of the outer cowling.

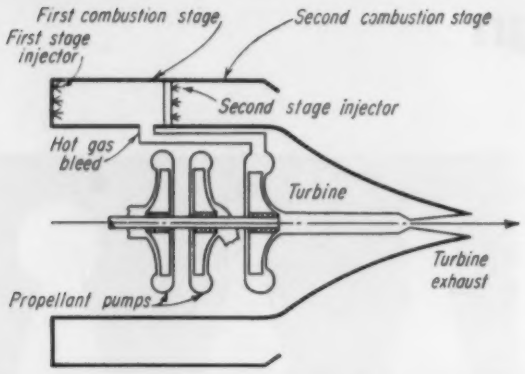


Fig. 5—Two-stage main combustion process and enclosed turbopump unit. A monopropellant is decomposed at a temperature suitable for partial bleed-off to the turbine. Second stage is produced by injection of the other propellant into the decomposed first stage. Alternate combustion methods are possible.

In addition, the thrust chamber is shorter than for other configurations, center of gravity is more favorably located simplifying gimballing problems and reducing actuating forces if the structure must be swivelled, and possibly resulting in a lighter weight engine.

Major problem is the large surface area in contact with the high temperature gases. The increased combustion chamber diameter also imposes structural problems. However, this configuration looks the most attractive as a building block to approach an integrated engine system.

AN INTEGRATED ENGINE

The available area within the spike makes possible the mounting of the turbopump unit and even the gas generator, Fig. 4. It is also possible to exhaust the spent turbine gases through the end of the spike and avoid the problems attendant to turbine exhaust flowback into the engine compartment.

Since the turbopump unit is now surrounded by an annulus containing hot gas, and as hot gas is needed to drive the turbine, the gas generator may possibly be eliminated. Bleed-off of some hot gas from the chamber and dilution with excess fuel would reduce the temperature to a level the turbine could handle. However, a two-stage main combustion process, Fig. 5, appears to offer even better potentialities.

These simplifications of the system do not exhaust all of the potentialities of the spike nozzle thrust chamber. It may be possible, within the restrictions imposed by the dimensions of the combustion chamber, to eliminate the turbine housing and the hot gas ducting by incorporating a topping turbine, Fig. 6, into the first stage combustion zone of the integrated engine system.

Finally, it may be conceivable that the turbine and pumps can be integrated into a single rotating component, Fig. 7. This engine represents the final configuration of this particular integrated engine design concept. Major problem: the dynamic interaction among the various components, possibly resulting in serious control problems.

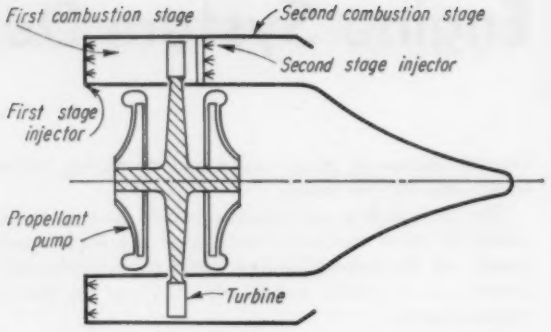


Fig. 6—Topping turbine and integral pump impeller eliminates turbine housing and gas ducting. Here, high turbine speeds are not required and a direct drive turbopump is feasible. Since only a small amount of the energy of the gases passing through the topping turbine is needed to drive the turbine, a low pressure drop, highly efficient turbine blade shape is used. Other refinements are possible that approach the final design concept.

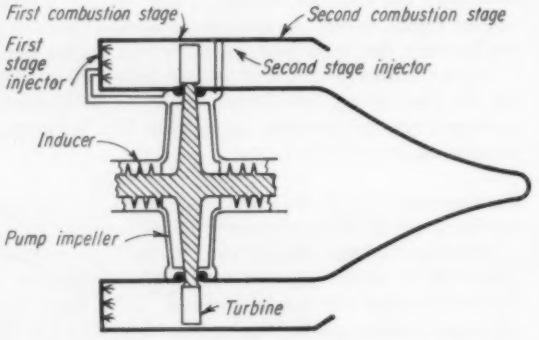


Fig. 7—Combined turbine and pump. Turbine disk includes both the fuel and oxidizer impellers as integral parts. Cooling of the turbine disk, if necessary, is easily accomplished by film or internal cooling. Although not the ultimate rocket engine configuration, it does indicate what can be accomplished by integrated engine system design.

CONCLUSION

The integration of the major components into an unconventional rocket engine configuration can result in performance, compactness, weight, and reliability advantages in comparison to a conventional engine composed of physically and functionally separated components. Other engine systems which may be more desirable for a specific application can be arrived at in a similar manner.

REFERENCE:

Factors Influencing the Application of Unconventional Rocket Engine Systems by George S. Gill, Supervisor, and Leo Kusak, Senior Research Engineer, Advanced Propulsion Unit, Research Subdivision, Rocketdyne, Conoga Park, California. Presented at the 1959 SAE National Aeronautic Meeting, New York, N. Y., March 1959, Paper No. 54S.

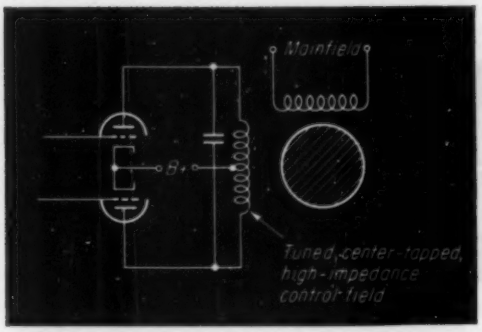


Fig. 1—Direct plate operation. By proper design the windings can be arranged so that net dc magnetization in the motor core is zero. This prevents dc saturation as well as extra drag and cogging.

Servomotor Modifications to Increase Flexibility

Modifications, both minor and complex, can extend servomotor flexibility to simplify control system design and packaging. Methods: exploit capabilities of standard motors; cooperate with manufacturer to obtain motors with unique characteristics; use a common motor package in which gear trains, dampers, tachometers are included within the motor frame.

From: Control Engineering

SIDNEY A. DAVIS
Consulting Engineer
East Norwich, N. Y.

Servomotor selection should start with a standard unit. There are a variety of two-phase standard Bu-Ord motors available from many sources. Recognized standards exist for both performance and reliability, hence selection and purchase should present no problem.

But sometimes there is no standard that exactly fits, and at other times use of a modified design allows system simplification, miniaturization, and improved reliability. Under these conditions a special servomotor may prove to give the best performance at the lowest cost. Available special features include special line voltage ratings, minimum control-field power, and varying the number of poles.

SPECIAL LINE VOLTAGE RATINGS

A variety of design modifications are possible by using special windings. Thus, without major mechanical changes or expensive retooling rated line voltage can be varied to achieve special performance of the motor at low cost.

A standard motor rated at 115v on its main and control phases, for example, can yield essentially the same performance when the two phases are wound for other rated voltages not necessarily equal for the two phases. Common ratings include 57.5v for magnetic amplifier operation, and 40v and 67.5v in transistor circuits. Special ratings are particularly important when, for reasons of economy or miniaturization, it is necessary to avoid transformers.

Some motors are designed so that the control field will operate at either of two voltages. For example, many Bu-Ord motors have divided control winding with a series-rated voltage of 115v and a parallel-rated voltage of 57.5v. Any such pattern is feasible.

MINIMIZING CONTROL-FIELD POWER

Special windings that minimize control-field power permit the use of a smaller servo amplifier. Main field power consumption is not as important except in its relation to the servomotor temperature rise. A simple way to reduce control-field requirements without loss of performance is to apply unbalanced power to the separate phases of the motor.

For example, a servomotor with a power rating of 6 watts per phase has a total permissible dissipation of 12 watts, based on temperature rise. If less power is used in the control phase and more power in the main phase, keeping the total power the same, a small amount of performance deterioration occurs. This can be found by considering the stall or zero-speed condition of the motor.

Servomotor torque is proportional to the product of main and control-field voltages. Keeping the main-field voltage constant, the torque varies linearly with control voltage. Power varies as the voltage squared; thus, stall torque varies as the square root of the product of the main and control-field powers. Dividing the 12 watts into a main field power of 9 watts and a control-field power of 3 watts, the ratio of torque for the new condition to torque under balanced conditions is:

$$\text{Torque ratio} = \sqrt{9 \times 3}/\sqrt{6 \times 6} = 0.866$$

Therefore, cutting control-field power in half reduces stall torque by only 13.4%.

This design variation may be carried out using other values of power. A 1 watt control winding with an 11

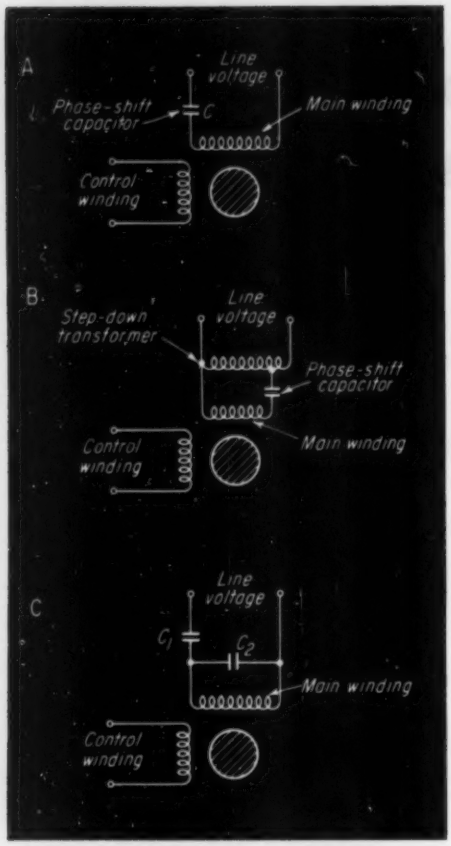


Fig. 2—Techniques for shifting main-field phase. (A) Series capacitor shifts phase 90°, but resonance builds up winding voltage above line voltage. (B) Step-down transformer compensates for resonant build up. (C) capacitors can be adjusted to give rated main-field voltage and 90° phase shift.

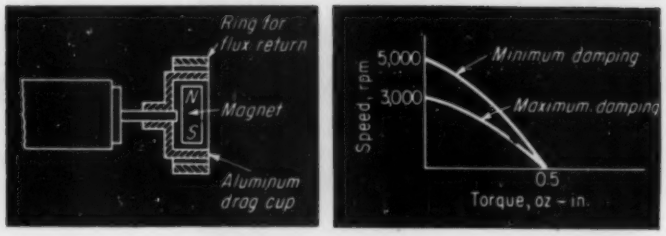


Fig. 3—Magnetic viscous damper on servomotor. Damping can be changed by a screw-driver adjustment. Speed-torque curves for the max and min adjustments on the drag damper of a typical servomotor.

Table I—Some Common Motor Packages

A. Motor + gearhead (possibly including antibacklash gears)
B. Motor + gearhead + slip clutch
C. Motor + tachometer (for either damping or integrating)
D. Motor + brake
E. Motor + viscous damper
F. Motor + inertial damper
G. Motor + gearhead + tachometer + brake
H. Motor + gearhead + damper + coupling + potentiometer

watt main winding cuts available torque by less than half, although control power is ½ of rated.

CHANGING THE NUMBER OF POLES

A large number of poles tends to give higher stall torques and lower no-load speeds, a combination that means good inherent motor damping. However, there is a limit established by the magnetizing current drawn by the servomotor. The greater the number of poles, the greater the percentage of input power that is dissipated as magnetizing losses, and the smaller the portion that is transferred to the rotor to generate torque.

Where high mechanical power output, and not damping, is the principal performance requirement, few poles give greater efficiency. Thus, more watts of shaft power can be drawn from a 4-pole motor than from an 8-pole motor in a given frame size, despite the higher stall torque of the 8-pole servomotor unit.

DIRECT PLATE OPERATION

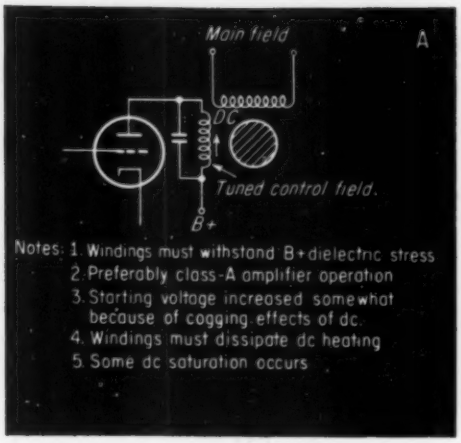
Miniaturization of servomotors has necessitated designs in which control-field impedances can be driven directly from the amplifier output circuits, not requiring an output transformer. Fig. 1 shows a common variation, in which the motor windings are designed to directly match the output circuit of a pair of triodes.

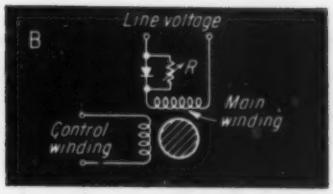
In specifying this type of servomotor, insulation requirements must be considered because of the high *B* voltage between the phases. Also, dissipation increases in the separate halves of the motor winding, although in class-*B* operation this is negligible as the quiescent current of a servomotor is approximately zero.

SHIFTING MAIN-FIELD PHASE

Several ways are used; the most common method, if a polyphase source is available, is to obtain the phase-shifted voltage directly. Another method: a capacitor is incorporated directly in the motor main field, Fig. 2(A), to shift the winding phase 90° with respect to the line. Problem is that resonance tends to build up motor winding voltage above line value.

To solve this problem, Fig. 2(B), a transformer steps down line voltage


Main field
A
DC
Tuned control field.
B+
Notes: 1. Windings must withstand B+ dielectric stress
2. Preferably class-A amplifier operation
3. Starting voltage increased somewhat because of cogging effects of dc.
4. Windings must dissipate dc heating
5. Some dc saturation occurs



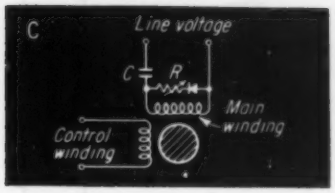


Fig. 4—Damping with rectifiers. (A) Quiescent dc in motor control winding. (B) Series rectifier gives dc damping; R is damping adjustment. (C) Series phase-shift capacitor C and shunt rectifier for dc damping.

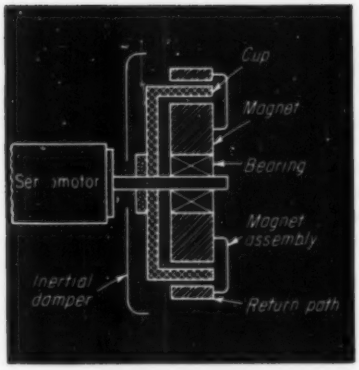


Fig. 5—Inertial damper. Under a constant-speed condition, servomotor, through the drag cup coupling, causes the magnet assembly to rotate. Magnet speed and shaft speed will be essentially equal, any differential being the result of residual bearing friction at assembly point.

to a value so that inserting the tuning capacitor in series with the main field, subjects the main field to rated voltage. When properly tuned, motor voltage will be Q times line voltage, where Q equals the tangent of the power factor angle. Two capacitors will avoid use of the transformer, Fig. 2(C). Disadvantage is need for two capacitors.

Most convenient solution is to design the motor so that with a single-series phase-shifting capacitor, as in Fig. 2(A), it will operate properly at the tuned voltage across the winding when rated line voltage is applied.

As a general rule, the capacitance required for tuning or phase-shifting purposes varies inversely with the square of the voltage. Thus low voltage units require high capacitance ratings, even though the voltage rating of the capacitor is proportionately lower. Net result: low-voltage-unit capacitors become bulky.

IMPROVING SERVOMOTOR DAMPING

The speed-torque curve of a two-phase servomotor shows that torque decreases with speed—or there is a drag torque proportional to speed exerted on the motor shaft. Drag torque is essentially pure viscous damping. This type of damping is the simplest as it is designed into the motor and can be optimized by selecting the proper number of poles and adjusting the conductivity of the rotor squirrel-cage bars.

If the inherent viscous damping is inadequate, supplementary damping is possible by modifying the rotor skew. For example, the no-load speed of a size-10 servomotor can be reduced from 6700 to 3500 rpm simply by reducing the skew. There is no reduction in stall torque. Technique is useful in medium performance servomechanisms, where an additional margin of stability is required.

For additional viscous damping, a drag cup, Fig. 3, of a low density, high conductivity material such as aluminum can be attached to the motor-shaft, and rotated in the field of a permanent magnet. Result: viscous drag proportional to speed.

Other methods, Fig. 4, may be compact and inexpensive but have a disadvantage, they introduce direct current in the windings which cogs the servomotor thus increasing the starting voltage.

Inertial damping, Fig. 5, is more complex but has special advantages. There is no reduction in output torque caused by drag on the motor shaft. But when the servomotor is at rest in an equilibrium position, any tendency to oscillate is damped by viscous coupling to the relatively massive magnet which can not follow rapid oscillations. The inertial damper thus provides viscous drag at null to damp out incipient oscillations, but does not subtract output torque at the motor shaft. Technique is useful where low velocity errors and high mechanical output are required. However, it does reduce servomotor accelerating ability, as the heavy magnet must be brought up to the motor speed.

PACKAGING OTHER SYSTEM COMPONENTS

Probably the greatest flexibility in system packaging can be achieved by combining within the motor frame many of the components that are frequently used separately. Table I lists some of the common packages extensively used in control systems.

REFERENCE:
Get the Most Out of Your Servomotor by Sidney A. Davis, East Norwich, N. Y. Published in Control Engineering, October, 1958, p. 80-83.

From: SAE Journal

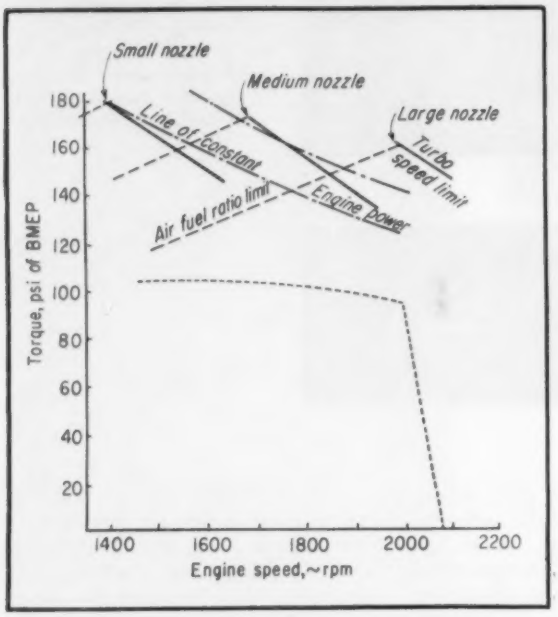


Fig. 1—Three turbocharger matchings for the same engine. The peak on the right is produced by using a large area turbine nozzle. The matching peak on the left is produced by a small area nozzle. Medium nozzle size represents the compromise.

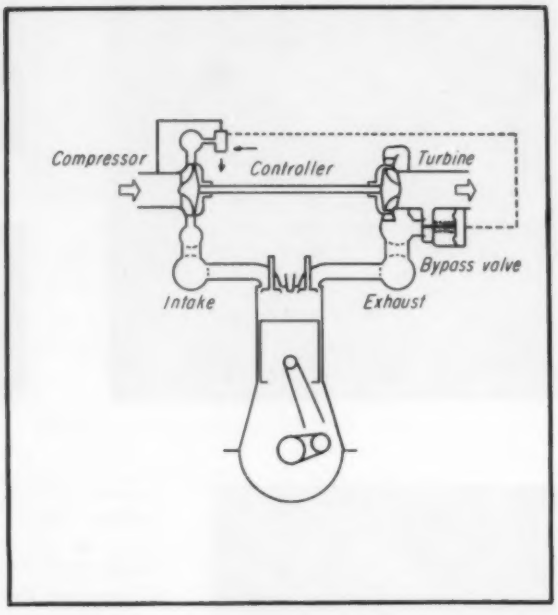


Fig. 2—Typical pressure-ratio controlled turbosupercharger. The controls keep the output of the turbocharger compressor at a constant pressure ratio over a wide range of engine operating conditions and improves performance.

Selecting the Right Turbocharger . . .

. . . for a high speed diesel engine requires an analysis of the engine, ambient conditions and the control system.

WILTON E. PARKER,
Manager AiResearch Industrial Division
The Garrett Corp.

Important considerations is matching turbochargers to high-speed diesel engines are: (1) the type of service for which the engine will be used; (2) the type of control system which will be used for both the engine and the turbocharger; and (3) the ambient temperatures and pressures to which the engine will be exposed during operation.

A common practice is to compare turbocharger performance by comparing only the merits of compressor charts. Comparisons of this type, though often valuable in selecting the proper size of turbocharger for a given engine, can lead to erroneous conclusions. Further, a comparison based solely on the comparison of component (that is, turbine, compressor, and mechanical) efficiency can likewise be misleading. Best performance depends on components efficiencies being high at the same engine operating point.

Much stress has recently been placed on the value of turbocharger acceleration. This is a debatable criterion as a figure of merit. What is more important is the condition or time at which the turbocharger reaches the cross-over point (the operating condition at which compressor exit pressure equals turbine inlet pressure).

After the cross-over condition is attained, a pressure

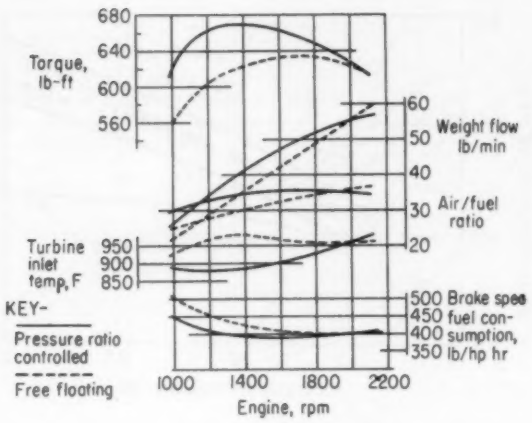


Fig. 3—Comparison of turbocharged diesel with and without pressure ratio control showing same engine characteristics.

differential exists which promotes good scavenging, lower exhaust temperatures, and better overall engine acceleration with less smoke. Good component efficiencies coupled with properly matched components will create the desirable condition. Until the condition is reached, maximum engine acceleration cannot be attained without excessive smoke regardless of turbocharger acceleration characteristics.

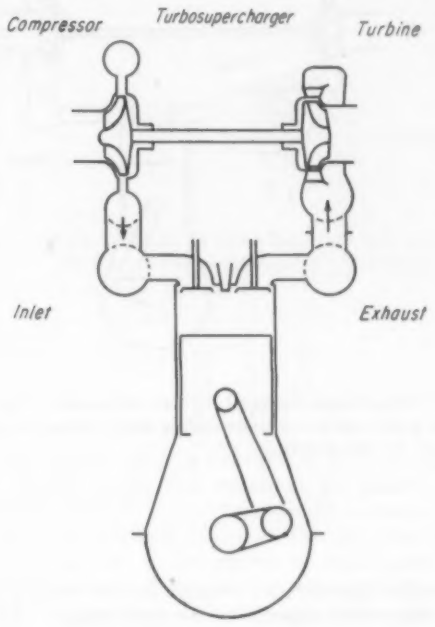
EFFECTS OF ENGINE USAGE

Three basic turbocharger matchings for the same engine are shown in Fig. 1. These curves indicate that there is available a choice of torque curves to fit special needs. The curve on the right is a typical propeller-type matching. It is used by ships, by railroads, and by electric powerplants. The middle curve would be very effective with "stiff" torque converters in pusher tractors or wheel tractors. The curve on the left should be of advantage with geared tractors or front-end loaders.

As an engine is more highly supercharged, its response rate becomes progressively more dependent upon the response rate of the supercharger. For example, a zero degree supercharged engine (naturally aspirated) needs no supercharger response to give full change in torque on demand.

A 50% supercharged engine can furnish about 100 bmep torque instantaneously upon fuel injection and relies on the supercharger to make the last 50 bmep available. For the 100% supercharged engine, the first 100 bmep is independent of supercharging; the last 100 bmep is dependent upon supercharge. The proportions have become 50% of torque instantly available, 50% dependent upon supercharging action. Thus, the highly turbocharged engine has characteristics which are a cross between the response characteristics of the naturally aspirated reciprocating engine and the gas turbine.

Several solutions of this problem are possible. One, the response rates required of the powerplant can be minimized. Torque converters operate in this direction.



How the Turbocharged Engine Works

Engine exhaust gas from the exhaust manifold powers a turbine which drives a centrifugal compressor. The compressor compresses atmospheric air and delivers it to the engine, thereby supercharging the engine. The wheel of the turbine and the impeller of the compressor are mounted on a common shaft. There are no mechanical connections to the engine.

The centrifugal compressor of the turbocharger consists of two elements, the impeller, or rotating part, and the diffuser. All the work is done on the air by the impeller and about half of the pressure rise takes place in it. The diffuser converts the velocity head of the air into the remainder of the pressure rise.

The turbine of the turbocharger also consists of two elements, the nozzle and the wheel. The nozzle is a ring of small openings aimed inward to produce a spiral or vortex flow of exhaust gas. Because the nozzle openings are small compared to the volume flow of the exhaust gas, a vortex of high velocity is formed. The turbine wheel is mounted inside the nozzle vortex flow and is driven by it.

The speed of the turbine is determined by the velocity of the nozzle vortex flow and by the power drawn from the turbine. All other things being equal, small nozzles drive the turbocharger to higher speeds, large nozzles produce lower speed. This action provides a principal means of matching the turbocharger to the engine.

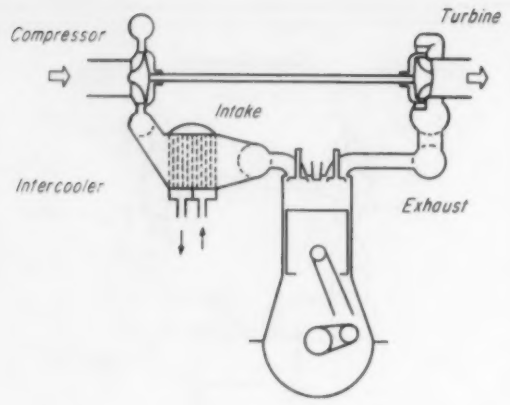


Fig. 4—Turbocharger equipped with an intercooler. Intercooler may be jacket water, a separate cooling water system, or ambient air. Last two are preferred.

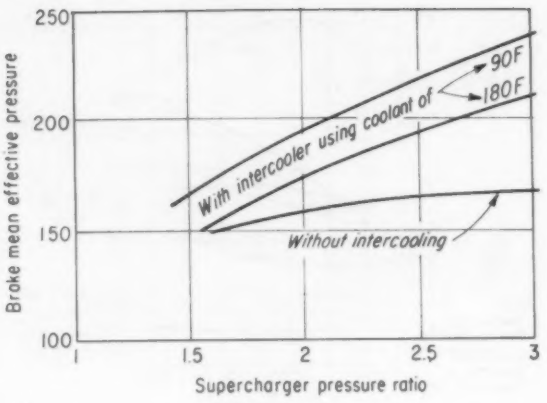


Fig. 5—Typical bmep of turbocharged engine for constant exhaust temperature and constant firing pressure (with and without intercooling) using coolants at two different temperatures.

As another approach, an attempt can be made to maximize the rate of response of the turbocharger. The use of turbocharger controls is a step in this direction.

PRESSURE RATIO CONTROLS

Turbocharger controls are typified by the system diagram shown in Fig. 2. Control is accomplished by measuring the actual compressor pressure ratio and using this signal to actuate a servo valve which regulates oil pressure (lubricating or fuel oil) to the bypass valve.

Bypass valve allows the exhaust either to go through the turbine or to bypass it, thus controlling turbine speed. The turbocharger is fitted with a nozzle which is much smaller in area than would be chosen for a free-floating turbocharger used with an engine of equivalent size and speed. This small nozzle keeps turbocharger speed at or near the desired maximum, regardless of altitude, throughout approximately the upper 50% of the engine speed and load range.

Pressure ratio controls minimize the time lag and smoke associated with accelerating the engine. This is important for vehicular and generating set applications. The control also affects the engine torque and brake specific fuel consumption (bsfc) curves as well.

A turbocharged diesel with and without pressure ratio control is compared in Fig. 3. Note that the torque rise is markedly increased through usage of the control. In actual service on trucks it has nearly halved the number of gear shifts on certain runs.

Torque ratio is not a function of input shaft speed. Torque converter input shaft torque is that developed by the engine. For a stalled converter, the required input shaft torque vs speed curve resembles a propeller curve. The lugging torque curve of a highly turbocharged engine drops off severely at low speed. This drop-off varies with the degree of supercharge. At extremely low speeds this drop-off curve is not too far from being parallel to a propeller curve.

This characteristic can cause a serious mis-match between a torque converter and its driving engine when loaded from low idle against a stalled converter. Also, instances where turbocharged engines matched closely to torque converters at sea level, could not, at altitude, get up enough engine speed against the stalled converter to develop a reasonable output torque along the torque droop line of the engine.

The converter, in turn, while maintaining a decent torque ratio, receives no torque from the engine at low speed. This results in a minute rim pull on the vehicle. Oppositely, there have been cases where by switching from one turbocharger to another, stalled torque converter engine speeds have increased markedly with obvious benefit to vehicle output.

Selection of the proper turbocharger coupled with use of the altitude-compensated pressure ratio control will go far toward alleviating the engine-torque converter matching variations which occur under varying altitude conditions. It will enable the engine torque output under low speed lugging conditions to stay above torque converter stall torque requirements until reasonable engine horsepower outputs are obtained.

Fuel consumption has been appreciably improved under part-load operation by providing sufficient excess air when using this control to give complete combustion even at part speed. Almost all conditions of operation show lower exhaust temperatures with the exception of maximum output which is relatively unaffected.

INTERCOOLING

Another way of getting a more dense charge into the engine is by cooling, Fig. 4, which cools the air leaving

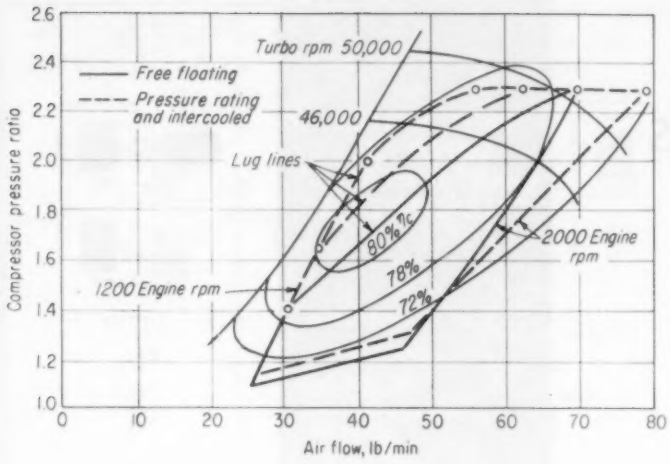


Fig. 6—Effect of turbocharger controls and intercooling on the selection of a turbocharger.

the compressor. The heat sink may be jacket water, a separate cooling water system, or ambient air. The greater the temperature difference between the charge air and the coolant the better the intercooling. This means that jacket water, though convenient, is not the best heat sink from a performance standpoint.

Intercooling generally results in lower charge air temperatures and pressures for a given power and boost pressure level. Results are lower exhaust temperatures and pressures, better internal cooling, lower firing pressures, and thus, lower engine mechanical and thermal stresses. On the other hand, it permits higher outputs for the same firing pressure and exhaust temperature, Fig. 5. Other helpful by-products are lower turbocharger speeds and temperatures, and hence longer life.

Indication of the range requirements for a turbocharger compressor when operated in conjunction with various devices which tend to give the utmost in performance is shown in Fig. 6. Note that both intercooling and pressure ratio controls impose additional range requirements on the turbo charger compressor. If the compressor does not have the required broad operating characteristics, it will be forced to operate either too far to the left and in surge, or too far to the right and in regions of very poor efficiency.

MISCELLANEOUS FACTORS

Various other factors affect the engine air consumption. One of these factors is valve timing.

Two turbochargers of different efficiencies can achieve the same air flow at the same density if provided with different engine valve timing. The tradition of high valve overlaps with turbocharged engines stems from inefficient turbochargers formerly available. However, an efficient turbocharger which produces large engine differentials so that the required air flow can be obtained with moderate valve overlap has a transient response advantage over an inefficient turbocharger used with high valve overlap.

Deceleration transients are of no direct importance; accelerations are of importance since they take place either in response to or in anticipation of an increase in load. During acceleration transients, the power torque equilibrium equation for the turbocharger includes a large term for inertia acceleration torque. The additional torque required is supplied at the expense of engine scavenging during the transient; that is, during acceleration transients large unfavorable differentials exist across the engine.

An engine with a relatively low overlap valve timing can at least be filled as a positive displacement machine although the combustion gases in the chamber at the time of inlet valve opening can be expected to move into the inlet ports. An engine with high overlap will, however, undoubtedly reverse scavenge; that is, a substantial initial flow of any burned gas from the chamber and exhaust manifold will flow into the intake manifold at intake valve opening. The low overlap engine will have substantially more oxygen trapped in the combustion chamber than will the high overlap engine under these transient conditions. There is, therefore, a real advantage with efficient turbochargers because they can produce high differentials which allow the use of the tightest engine valving for a given air flow.

Consideration should be given to the expected extremes of ambient pressures and temperatures. An increase of ambient temperature tends to make the turbocharger run faster and flow a greater volume of air at higher pressures but at reduced density. The effect results in higher exhaust temperatures and a move of compressor flow requirements toward surge.

A decrease of ambient temperature also results in a faster running turbocharger, thus higher pressure ratios, and again moves the compressor requirement closer to surge. At the maximum power point, however, air weight flow also decreases because of poorer scavenge differentials and tends to lower compressor efficiencies resulting again in higher exhaust temperatures.

REFERENCE:

Selecting the Right Turbocharger by Wilton E. Parker, Manager, AiResearch Industrial Div, The Garrett Corp, Los Angeles, California. Published in the SAE Journal, Nov, 1958, p 42-45.

From: Westinghouse Engineer

Matching Drives to Loads

Adjustable-speed drives are numerous but more costly and complicated, thus more difficult to select than constant-speed drives. A good approach to adjustable-speed drive selection is through matching the natural characteristics of drive outputs to load reqiurements.

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Selection of a suitable adjustable-speed drive can be simplified considerably by comparing the inherent characteristics of the drives to the load requirements. Load requirements can be divided into three categories: constant torque, constant horsepower, and variable torque. Available adjustable-speed drive systems have inherent capabilities of either constant torque or constant horsepower.

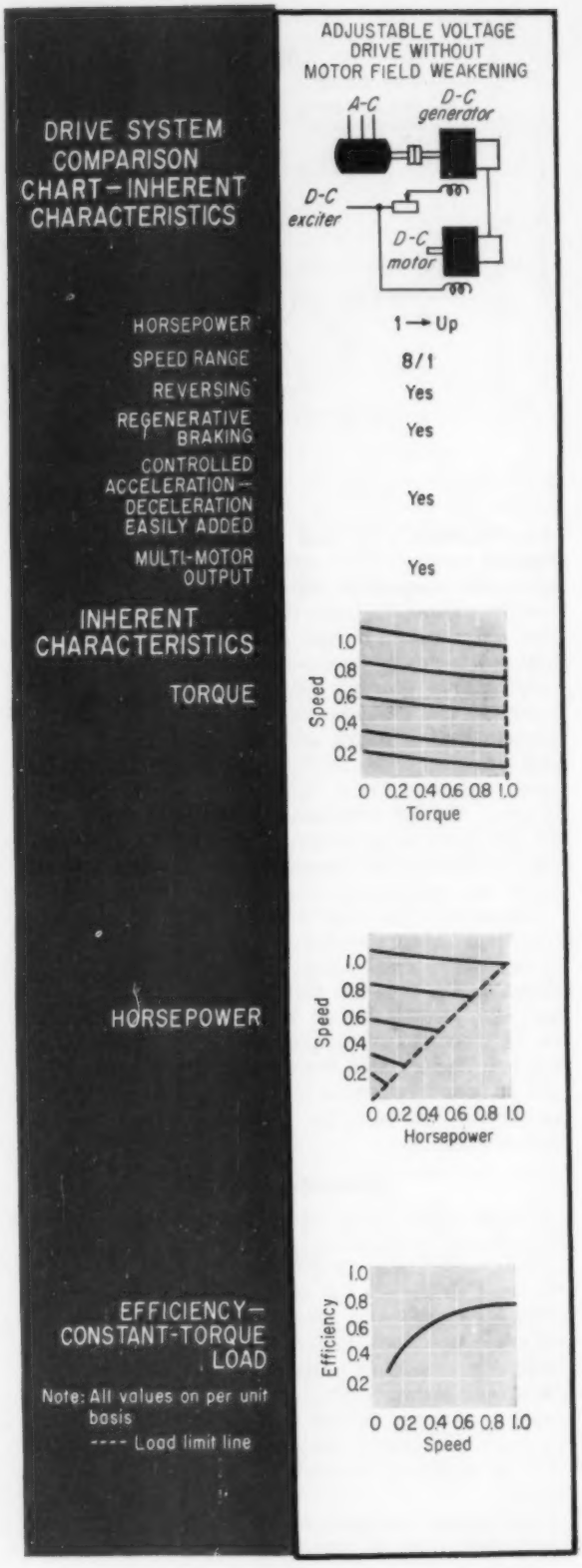
Drive selection on the basis of matching the natural characteristics of the drive to the natural load characteristics achieves maximum use of materials, so that the drive for a given machine is adequate for the load demands, but not oversized. Correct selection results in minimized initial cost and reduced operating cost.

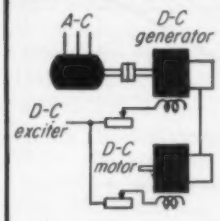
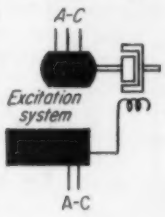
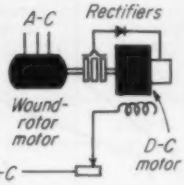
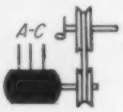
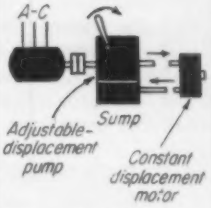
TYPES OF LOADS

Matching the drive to the load begins with analysis of the load—whether constant torque, constant horsepower, or variable torque. Special consideration is given to duty-cycle requirements, which could involve any one or more of these three basic characteristics.

Constant-torque loads result from overcoming friction or exerting tension, and remain practically constant regardless of the speed of operation. Examples of constant-torque loads created by friction are: conveyors, gear-type pumps, printing machines, slitters, load lifting and others.

Tension-exerting drives also have constant-torque requirements. Tension-exerting refers to the presence of



ADJUSTABLE VOLTAGE DRIVE WITH MOTOR FIELD WEAKENING	EDDY CURRENT CLUTCH DRIVE	RECTIFLOW DRIVE	MECHANICAL ADJUSTABLE-SPEED UNITS	HYDRAULIC DRIVE
				
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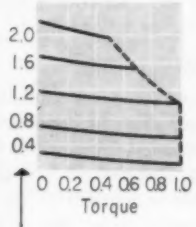
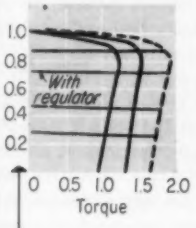
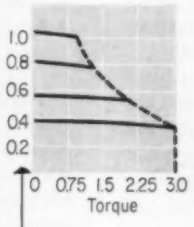
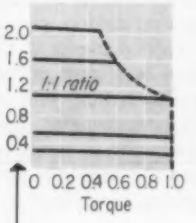
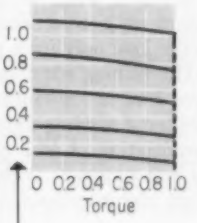
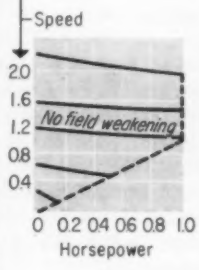
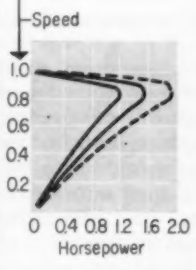
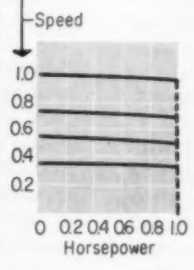
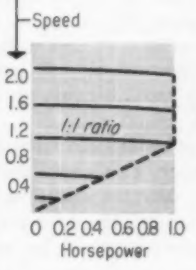
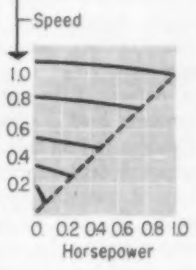
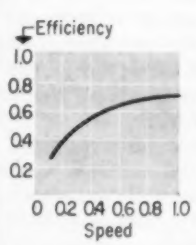
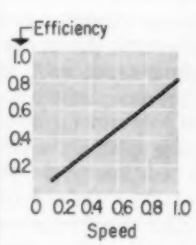
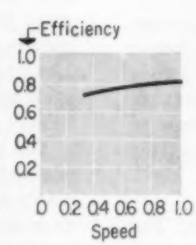
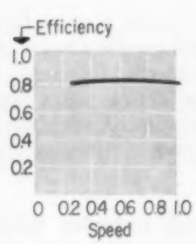
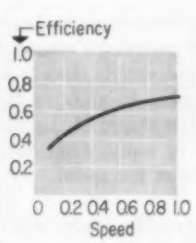
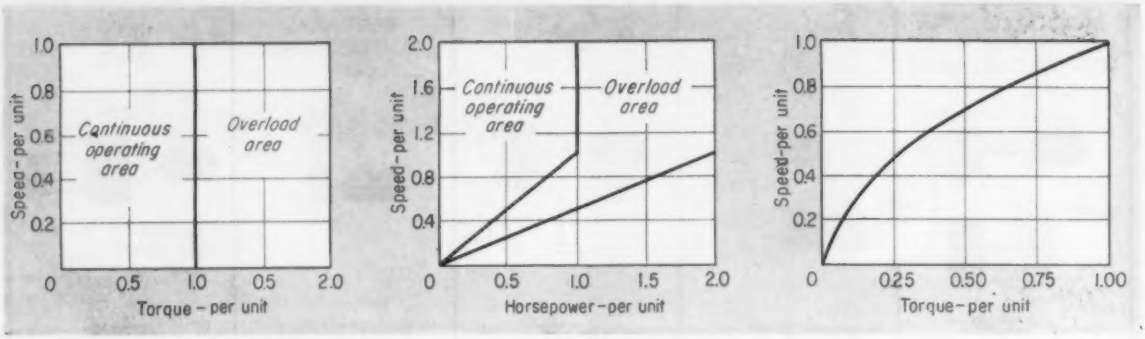
Yes	Yes — Function matching regulator needs	No	No	No
				
				
				



Load requirements can be divided into . . . three categories. (Left) constant-torque loads require extra torque for breakaway, acceleration and deceleration. (Center) constant-horsepower loads require extra horsepower for the same factors. (Right) variable-torque load devices increase with the square of the operating speed.

back tension to create a constant tension in a material being processed. It can be either a mechanical device such as a brake, or an electric device can be used. Tension may be required to stretch a product or to create a tight or uniform wrap, as in the instance of material being wound on a core. Back-tension devices give a constant-torque load only for a particular diameter of the roll.

The turning effect required by a crane or hoist to lift a given load is constant-torque in nature, with the load exerted on a winding drum of fixed diameter. Normally, the consideration of load requirements in terms of torque is the best approach, as the use of horsepower terms involves speed, and calculation errors are more likely to occur.

Constant-horsepower loads demand high torque at low speeds and low torque at high speeds. A lathe is a good example. Assume that a given chip is to be removed at constant cutting speed at several radii on a workpiece. The torque required at 1 in. radius will be only ¼ of that at a 4 in. radius. If the cutting speed is constant, a constant-horsepower load is created.

Tandem rolling-mill drive motors are rated at constant horsepower over a speed range. This allows reduction of a variety of materials having different metallurgical characteristics. On such an application, the drive is operated at constant torque for any given material by setting each motor shunt field strength at a predetermined value before operation is begun.

Variable-torque loads are created by blowers, fans, agitators, and centrifugal pumps, which require a much lower torque at low speeds than at high speeds. In general, the torque required in such centrifugal devices varies approximately as the square of the operating speed, while the volume of gas or liquid displaced at constant pressure varies as the cube of the speed.

Duty-cycle loads occur with processing machines. The cycle of operation is such that the selection of motor size can be made to minimize the motor rating. Drives for cranes and hoists always take advantage of duty cycles. When the operating cycle is such that the idle or reduced-load time is 25% or more of the elapsed time, a duty-cycle consideration is warranted for the application.

Any motor for a duty-cycle application must have adequate torque to meet the peak load requirements, and adequate thermal capacity to carry the load continuously. A flywheel can be used to reduce the peak load needs.

TYPES OF DRIVES

The first cost of an adjustable-speed drive is considerably greater than that of a constant-speed drive of comparable capacity. For this reason, more care is usually given to the selection of these drives to be sure that the drive is adequate and yet not oversized. All drives considered have a natural constant-speed characteristic (except the eddy-current clutch) with a maximum load capability. The eddy-current clutch has a natural constant-torque characteristic with a maximum load capability.

Adjustable-voltage drives without field control has been available for many years using motor-generator power supplies, and recently using reactor-semiconductor power supplies. The drive has a natural constant-speed characteristic with a constant-torque capability. That is, the torque requirements must not exceed a given amount, regardless of operating speed. Adjustable voltage drives are easily operated over an 8 to 1 speed range, and greater speed range can be obtained with some alteration.

The most attractive qualities of the adjustable-voltage drive are the ability to absorb power during deceleration when the motor generator power supply is used, and to operate multi-motor processing drives over a speed range. The characteristics of such drives allow the motors to work together, using inherently flat speed-load characteristics or with only minor control influence.

The drive is relatively expensive in first cost, and its efficiency is reduced by the chain of machines that the power must transfer through (ac motor, dc generator, and dc motor). The efficiency is nearly constant over one-half speed, but it is limited to about 70% maximum by the chain of three machines. In units above 200 hp, efficiency of the system is improved since each machine has an efficiency of over 90%.

Adjustable-voltage drive with motor field control gives an increased speed range and is a variation of the adjustable-voltage drive described above. Comparing motors at the same top speed value, the speed range achieved by field control results in an increase in dc motor drive size proportional to the increase in speed range above full field. This increased speed range is at constant-horsepower and reduced torque values. Thus, the drive is capable of delivering constant torque up to full-field speed of the dc motor, and constant horsepower above.

Common application of the adjustable-voltage drive with field weakening include machine tools and others where torque requirements are reduced at higher speeds. A good example of a constant-horsepower drive as part of a multi-motor drive system is found in a textile slasher. Constant yarn tension is maintained by a regulator which adjusts the dc motor shunt field according to the loom beam diameter to maintain constant armature current. At operating speed, the beam motor terminal voltage is constant and the beam drive is regulated to hold constant horsepower for the length of the cycle.

Rectiflow drive system uses the basic constant-horsepower Kramer drive system in which the secondary power from a wound-rotor motor is rectified and applied to a dc motor on the same shaft. The size of a dc machine and rectifiers is related to the operating speed range. If the system is to give a 2 to 1 speed range, for example, the dc motor must be capable of handling one-half of the main motor rating at one-half of its speed, and it will be as large in torque capacity as the main motor.

Semiconductors have made this drive practical in small sizes. Also, the natural horsepower characteristics of the drive are desirable for constant-horsepower applications such as machine tools. Rectiflow drive can be used for driving pumps which require only small speed adjustments. Efficiency remains high and first cost is favorable even though the unit is oversized at lower speed.

High efficiency over the operating speed range is an outstanding feature. The relatively flat, natural speed-load characteristic is useful when good regulation is needed without use of a regulator. Rectiflow drive has the starting characteristics of an ac wound-rotor motor plus the high starting torque of the dc drive.

As the unit is basically a constant-horsepower drive, when applied to a constant-torque load, the full capacity of the equipment is not used at reduced speeds.

Eddy current clutch makes use of a drag created by a rotating magnetic field inside a soft iron cylinder. Eddy currents are produced in the cylinder and torque is exerted according to the strength of the magnetic field. Slip loss is proportional to slip rpm.

When operating at half speed with a constant torque load, 50% of the motor output is dissipated in heat loss in the clutch. Because of high losses at low speed, the operating cost can be high, especially in continuous-duty, high-horsepower sizes where the power cost is appreciable.

Clutch is poorly suited for application to drives requiring constant horsepower because it must be oversized. A 10 hp, 4 to 1 speed range load requiring constant horsepower, for example, would use ¼ of the clutch torque capacity at top speed; at 25% speed, three times as much power would be lost as delivered to the load.

Best applications for the eddy current clutch are the pump or fan characteristic loads, because the inherent characteristics of the clutch and the requirements of the load are well matched. Also, the load falls off rapidly at low speed and good operating efficiency is achieved. The eddy current clutch can give smooth acceleration to a constant operating speed application, such as may be required by small or medium processing equipment.

Mechanical speed changers include adjustable sheaves, V-belts, chain drives, as well as ball and disk-friction devices. These are theoretically constant-horsepower drives with the size of the ac driving motor and the mechanical speed changer selected to be compatible. The speed-range and torque capability is limited by the mechanical device, and changes up to 10 to 1 are available, although 6 to 1 is more normal.

Usually, mechanical speed-changing devices are rated at constant-horsepower above the 1 to 1 ratio; below the ratio, they are rated at constant torque.

Simplicity and availability, as well as low first cost, make these devices attractive for small drives requiring speed adjustment. On larger sizes, they become impractical because of physical limitations of parts.

Hydraulic drives are similar to the adjustable-voltage drive system in that an induction motor furnishes power to an adjustable displacement pump, which drives the hydraulic motor. Again, the efficiency is affected by three elements in the chain. Efficiency is also similar, as the top system operating efficiency is about 67%.

The hydraulic system is usually supplied as a constant-torque drive using an adjustable-displacement pump to supply a constant-displacement motor. Speed of the motor varies as the volume of fluid pumped to it, and the output volume of the pump varies with displacement.

A constant-horsepower drive system can be arranged by varying the displacement of the motor. The adjustable-displacement motor is more expensive and complicated than the constant-displacement pump, just as the electric drive with motor field weakening is more expensive for a given horsepower rating than the constant-torque drive.

The hydraulic system can be adjusted over a large range of speed and can be reversed easily. The same amount of control circuitry is required as for an electric system with the same regulation qualities.

Chief disadvantage is the possibility of oil leaks. Hydraulic drive accuracy depends on close mechanical tolerances in the pump, motor and regulating system when used. Thus, with use and time the wearing parts must be replaced to preserve drive accuracy.

REFERENCE:

Machine Drives to Loads by M. H. Fisher, Manager, General Mill Section, Industrial Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania. Published in The Westinghouse Engineer, May 1959, p 66-70

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(H-1) **Gasoline Engines**—Bulletin, 4 pp. Illustrates and briefly describes complete line of single cylinder, air-cooled gasoline engines, 2 to 9 hp. Briggs & Stratton Corp, Milwaukee 1, Wis.

(H-2) **1-40 Hp Ac Motors**—Bulletin, 4 pp. Describes operation and its advantages in motor design. Windup, encapsulated in plastic, is impervious to chemical, moisture, abrasive or thermal damage. Lincoln Electric Co, 22801 St Clair Ave, Cleveland 17, Ohio.

(H-3) **Manual Starters**—Catalog, 8 pp. For all applications where remote control or low voltage protection is not a factor. Complete information including prices, ratings, and dimensions for open-type general purpose water-tight and flush-type enclosures. Furnas Electric Co, 1050 McKee St, Batavia, Ill.

(H-4) **Motor Controls**—Catalog, 56 pp. Describes magnetic starters and contactors, push buttons, drum controllers, foot switches, pressure switches as well as related pilot devices. Includes ratings and prices. Furnas Electric Co, 1050 McKee St, Batavia, Ill.

(H-5) **Motors and Blowers**—Catalog, 16 pp. Describes dimensional and basic performance data of subfractional hp motors and blowers. Heinze Electric Co, 685 Lawrence St, Lowell, Mass.

(H-6) **Air-cooled Engines**—Catalog, 28 pp. Shows range of 4-cycle, short stroke, air-cooled engines for various applications requiring from 3 hp to 24 hp. Kohler Co, Kohler, Wis.

(H-7) **Cranking System**—Brochure, 16 pp. Describes construction, operation, application and other features of cranking system for gasoline and diesel engines. American Bosch Div, American Bosch Arma Corp, 3664 Main St, Springfield, Mass.

(H-8) **Electromechanical Timers**—Catalog, 28 pp. Presents details of design, function, application, dimensions, wiring diagrams, time ranges and ratings; also synchronous and dc motors; contains pricing and ordering information. Cramer Controls Corp, Centerbrook, Conn.

(H-9) **Servomechanical Parts**—Catalog, 32 pp. Dimensions, specifications, applications for line of Class II gears, differentials, couplings, dial assemblies, limit stops, hangers and miscellaneous parts for servo systems. ¼ in. and ⅜ in. shaft sizes. Reeves Instrument Corp, Garden City, NY.

(H-10) **Fractional Hp Motors**—Bulletin, 4 pp. Synchronous and induction fractional hp motors, 1/75-1/30 hp. Electrical and mechanical specifications with outline drawings. Holtzer-Cabot Div, National Pneumatic Co, Inc, 125 Amory St, Boston 19, Mass.

(H-11) **Vertical Hollow Shaft Motors**—Bulletin, 4 pp. Describes design, construction, lubrication and ventilation of motors; gives engineering information as well as dimensions and specifications. Ideal Electric & Mfg Co, First and Oak Sts, Mansfield, Ohio.

(H-12) **Fhp Variable Speed Drives**—Catalog, 16 pp. Describes drive, how it works, typical applications, gives dimensions, ratings, ordering information and installation suggestions. The Zero-Max Co, Subsidiary of Revco, Inc, 1900 Lyndale Ave S, Minneapolis 5, Minn.

(H-13) **Electromagnetic Control**—Catalog, 172 pp. Includes information on automatic tranfer and remote control switches, contractors, relays, solenoids and electric plant controls. Electrical specifications, prices, charts, applications and construction information. Automatic Switch Co, Florham Park, NJ.

(H-14) **Automatic Starting Controls**—Bulletin, 6 pp. Includes prices of controls intended for fully automatic starting and stopping of engine driven generator sets. Automatic Switch Co, Florham Park, NJ.

(H-15) **Electric Fuel Pump**—Brochure, 4 pp. Description of electric fuel pump and applications. Bendix-Elmira, Eclipse Machine Div, Bendix Aviation Corp, Elmira, NY.

(H-16) **Motor Starters**—Catalog, 16 pp. Ac across-the-line; reduced voltage, primary resistor, auto-transformer, and secondary resister types; combination circuit breaker and disconnect-type across-the-line. Monitor Controller, 99 Grove St, Rockland, Mass.

(H-17) **Fhp Motors**—Bulletin, 12 pp. Lists reducer and nonreducer motors. 1/2000 to 1/6 hp. Torque ratings up to 219 in. lbs. Bodine Electric Co, 2500 W Bradley Place, Chicago 18, Ill.

(H-18) **Synchronous Motors**—Brochure, 4 pp. 40, 60, and 80 in. oz high torque, unidirectional and reversible, synchronous motor in output speed from 1 to 3600 rpm. Price list included. Also includes specifications and drawings. Hurst Tool & Mfg Co, Inc, Princeton, Ind.

(H-19) **Fhp Motors**—Catalog, 8 pp. Example of economics and application of engineered motors to fit the job. Franklin Electric Co, Inc, 400 E Spring St, Bluffton, Ind.

(H-20) **Fractional Hp Motors**—Bulletin, 10 pp. Describes construction of polyphase, capacitor start, split phase and permanent split capacitor motors in NEMA frames 56 and 48. Robbins & Myers, Inc, Fractional Motor Div, 1345 Lagonda Ave, Springfield, Ohio.

(H-21) **Fractional Hp Motors**—Catalog, 18 pp. Contains outline drawings and descriptive data on complete line of motors and speed reducers. Rae Motor Corp, 2009 Kewaunee St, Racine, Wis.

(H-22) **Permanent Magnet Dc Motors**—Bulletin, 4 pp. Describes design features of gearheads, tachometer generators, radio noise filters, centrifugal blowers and dynamic braking types. Includes wiring diagrams. Barber-Colman Co, Electrical Components Div, Rock St, Rockford, Ill.

(H-23) **Dc Motors**—Bulletin, 1 p. Contains features, diagrams and typical production specifications. Barber-Colman Co, Electrical Components Div, Rock St, Rockford, Ill.

(H-24) **Small Ac Motors**—Catalog, 48 pp. Describes fractional hp ac shaded pole induction motors, nonsynchronous unidirectional and reversible types, synchronous unidirectional types, geared and nongeared. Specifications, applications, performance curves and ordering data. Barber-Colman Co, Small Motors Div, Rock St, Rockford, Ill.

(H-25) **Servomotors, Generators and Synchros**—Catalog, 16 pp. Describes standard servo motors, motor tachometer generators, synchros and resolvers; electrical and mechanical specifications, dimensions and photographs. Kearfoot Co, Inc, 1500 Main Ave, Clifton, NJ.

(H-26) **Tachometers and Accessories**—Catalog, 10 pp. Describes full line of tachometers, adapters, gear boxes, manual and magnetic clutches, flexible shafting, and hub-odometers. Actuator Products Corp, Div of Geartronics Corp, 40 Nashua Street, Woburn, Mass.

(H-27) **Fhp Motors**—Catalog, 6 pp. Descriptive information and ratings of shaded pole, permanent split capacitor and series motors. Universal Electric Co, 300 E Main St, Owosso, Mich.

(H-28) **Fhp Motors**—Catalog, 12 pp. Carries complete but brief construction and application information, ratings, dimensions, and operating characteristics on the entire motor line. General Electric Co, Schenectady 5, NY.

(H-29) **Integral Hp Motors**—Bulletin, 4 pp. Describes weatherproofing and guard features, typical performance curves and construction details; sizes from 182 frame to 326 U. Marathon Electric Mfg Corp, Wausau, Wis.

(H-30) Motor Control—Brochure, 8 pp. Describes breather filters for crankcases of engines and compressors, gear cases, hydraulic equipment liquid storage tanks, machinery housings. Air Maze Corp, 25000 Miles Rd, Cleveland 28, Ohio.

(H-31) Motor Control—Brochure, 8 pp. General data and description of electronic variable speed drive systems with application data and model descriptions. Electro-Devices, Inc, Servospeed Div, PO Box 2308, Paterson, NJ.

(H-32) Motor Controls—Catalog, 80 pp. Technical data, dimensions, weights and prices of motor controls line. Also includes accessories and replacement parts. Arrow-Hart & Hegeman Electric Co, 103 Hawthorne St, Hartford 6, Conn.

(H-33) Controls—Bulletin, 4 pp. Representative products of the entire corporate line with application information. Controls Co of America, 2450 N 32nd St, Milwaukee, Wis.

(H-34) Adjustable Speed Drive—Bulletin, 8 pp. Gives advantages, technical data, dimensions and schematic of packaged drive; includes power unit, drive motor and operator's control. General Electric Co, Schenectady 5, NY.

(H-35) Speed Variator—Bulletin, 16 pp. Describes design, construction, operation and application of 1-200 hp line of speed variator adjustable voltage dc drives. General Electric Co, Schenectady 5, NY.

(H-36) Motor Reducers—Bulletin, 28 pp. Includes selection, dimensions and application information for the complete line with rerated NEMA standard motors up to 75 hp capacity. The Falk Corp, 3001 W Canal St, Milwaukee 1, Wis.

(H-37) General Purpose Motor Controls—Catalog, 87 pp. Describes general controls with price, specifications, performance charts and other technical data. General Electric Co, 901 W Burlington Ave, Western Springs, Ill.

(H-38) Servoassemblies—Catalog, 46 pp. Pictures, outline drawings and specifications of servo packages and electromechanical assemblies. Bowmar Instrument Corp, Box 2835, 8000 Bluffton Rd, Fort Wayne, Ind.

(H-39) Dc Motors and Equipment—Bulletin, 11 pp. Describes features, uses, ratings, sizes and capabilities of various models in the line. General Electric Co, Schenectady 5, NY.

(H-40) Dc Generator—Brochure, 22 pp. Describes principle of operation, advantages and applications. Illustrated with photographs, schematics, charts and graphs. General Electric Co, Schenectady 5, NY.

(H-41) Electromechanical Controls and Components—Catalog, 48 pp. Illustrates snap-action switches and actuators, lighted controls, hermetically sealed one way impulse and limit switches. Electrosnap Corp, 4218 W Lake, Chicago 24, Ill.

(H-42) Ac Specialty Motors—Bulletin, 4 pp. Gives application and performance data along with a rating chart and dimensions. General Electric Co, Schenectady 5, NY.

(H-43) Fractional Hp Motors—Catalog, 6 pp. Describes operation and application of 2, 2¾, and 3 in. diameter motors for axle shifting and power assists on trucks, automobiles and marine service. American Bosch Div of American Bosch Arma Corp, 3664 Main St, Springfield 7, Mass.

(H-44) Adjustable Speed Drive—Bulletin, 10 pp. Describes features, applications, basic circuit and cooling method. Also contains ratings, dimensions and installation photographs. Electric Products Co, 1725 Clarkstone Rd, Cleveland 12, Ohio.

(H-45) Motor Generator Sets—Catalog, 110 pp. Contains discount and price information, mechanical and electrical specifications, photographs and wiring diagrams for multi speed, wound rotor, special purpose and brake motors. Also includes motor controls, generators, and others. Marble-Card Electric Corp, Affiliated with Marble-Arms Corp, Gladstone, Michigan.

(H-46) Time Controls—Catalog, 4 pp. Portrays sampling of basic designs available for time controls in accordance with manufacturers' specifications. Includes photographs of interval timers, cams and synchronous timing motors. Paragon Electric Co, 1633-12th St, Two Rivers, Wisc.

(H-47) Fractional Hp Motors—Catalog, 10 pp. Electrical and mechanical descriptions, charts, graphs, sales and selection data. Howard Industries Inc, 1760 State Street, Racine, Wisconsin.

(H-48) Motors—Catalog, 4 pp. Covers diameters, ratings and specifications for line of shaded pole, induction and geared motors. Small Motors Inc, 2076 Elston Ave, Chicago 14, Ill.

(H-49)—Synchronous Motors and Generators—Bulletin, 30 pp. Gives construction details, features, applications, speeds and description of parts. Electric Products Co, 1725 Clarkstone Road, Cleveland 12, Ohio.

(H-50) Motors—Catalog, 5 pp. Description, uses and features of shaded pole, permanent split capacitor and brush types. Universal Electric Co, 300 E Main Street, Owosso, Michigan.

(H-51) Synchronous Timing Motors—Brochure, 9 pp. Description of synchronous timing motors and timers, together with speeds available, shafts furnished, and other technical data. Britsol Motors Div of Vocaline Co of America, Inc, Coulter St, Old Saybrook, Conn.

(H-52) Industrial Diesel Engines—Brochure, 8 pp. Describes parts, dimensions, and shipping specifications as well as ratings and performance curves. French, German and Spanish translations are included. F Perkins Ltd, 60 Wingold Ave, Toronto 10, Ontario, Canada.

(H-53) Controls—Bulletin, 8 pp. Gives dimensions, features, operations and applications of shaft, valve, product blending and machine tool controls. The Jordan Co, Inc, 3235 W Hampton Ave, Milwaukee 9, Wisc.

(H-54) Timing Motors—Bulletins, 4 pp. Describes construction and types of timing motors available. Includes ordering information and specifications. The F. Ingraham Company, Bristol, Conn.

(H-55) Control Units and Stations—Bulletin, 19 pp. Gives ratings, types, design features, accessories, enclosures and mounting data. Describes unit construction and operation method of various models. Allen-Bradley Co, Milwaukee, Wis.

(H-56) Motors—Brochure, 8 pp. Describes design features and facilities for engineering and service. Makes motoreducers, fluid shaft, machine tool, torque and pump motors in addition to other models. Reuland Electric Co, 3001 W Mission Rd, Alhambra, Calif.

(H-57) Blower Wheels and Assemblies—Catalog, 6 pp. Gives dimension and selector charts, with products shown in outline drawings. Morrison Products, Inc, 16816 Waterloo, Cleveland, Ohio.

(H-58) Fhp Motors—Brochure, 8 pp. Illustrations of representative motors and gearmotors, ac and dc, facilities and methods of operation. The Lamb Electric Co, A Division of American Machine & Metals, Inc, Lake St, Kent, Ohio.

(H-59) Synchronous Motors—Bulletin, 12 pp. Gives characteristics, ratings and specifications of synchronous ac motor that can also be used as dc stepping motor. The Superior Electric Co, 83 Laurel St, Bristol, Conn.

(H-60) Power Amplifier—Bulletin, 4 pp. Covers the specifications, capabilities and operation of universal type amplifier. Used to drive two phase ac servo motors, or dc torque motors providing for command-feedback input signal summation, comparison, or difference. The Oilgear Co, 1560 W Pierce St, Milwaukee 4, Wisc.

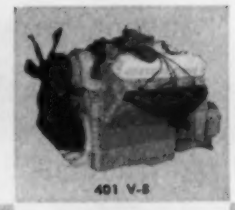
(H-61) Fhp Motors—Bulletin, 8 hp. Operating data, tables and dimensions for fractional hp geared motors. Merkle-Korff Gear Co, 229 N Morgan St, Chicago 31, Ill.

(H-62) Continuous Power System—Bulletin, 6 pp. Describes ac and dc power system used in connection with a storage battery to provide instantaneous and continuous power during emergencies and power failures. Electric Products Co, 1725 Clarkstone Road, Cleveland 12, Ohio.

(H-63) Industrial Engines and Power Units—Brochure, 2 pp. Contains specifications for 4- and 6-cylinder, V-8 and diesel engines available as foot-mounted or skid-mounted power units, open or closed models. Includes applications and photographs. Industrial Engine Dept, Ford Motor Co, PO Box 598, Dearborn, Mich.

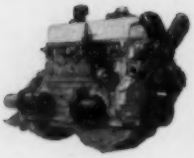
534 V-8

477 V-8

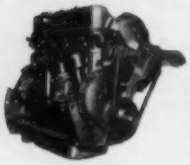

401 V-8

332 V-8

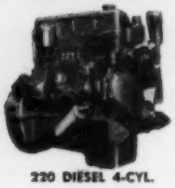
272 V-8


223 6-CYL.

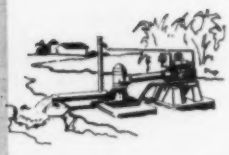
173 4-CYL.

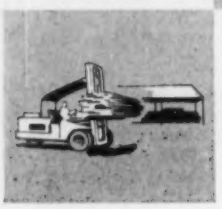

134 4-CYL.

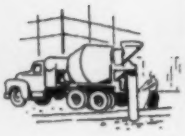
330 DIESEL 6-CYL.


220 DIESEL 4-CYL.

NOW...TEN FORD INDUSTRIAL ENGINES TO MEET YOUR POWER NEEDS!







Whatever your application, consider the many advantages you get with a Ford Industrial Engine.

Completely modern throughout, all Ford engines have Short Stroke design for increased operating economy . . . overhead-valve construction for quick, easy servicing . . . and provide more horsepower per pound of engine weight than ever before possible. To cut costs on *big* jobs, Ford offers 3 new Super Heavy Duty V-8's with totally new lubrication-, cooling-, and fuel-systems.

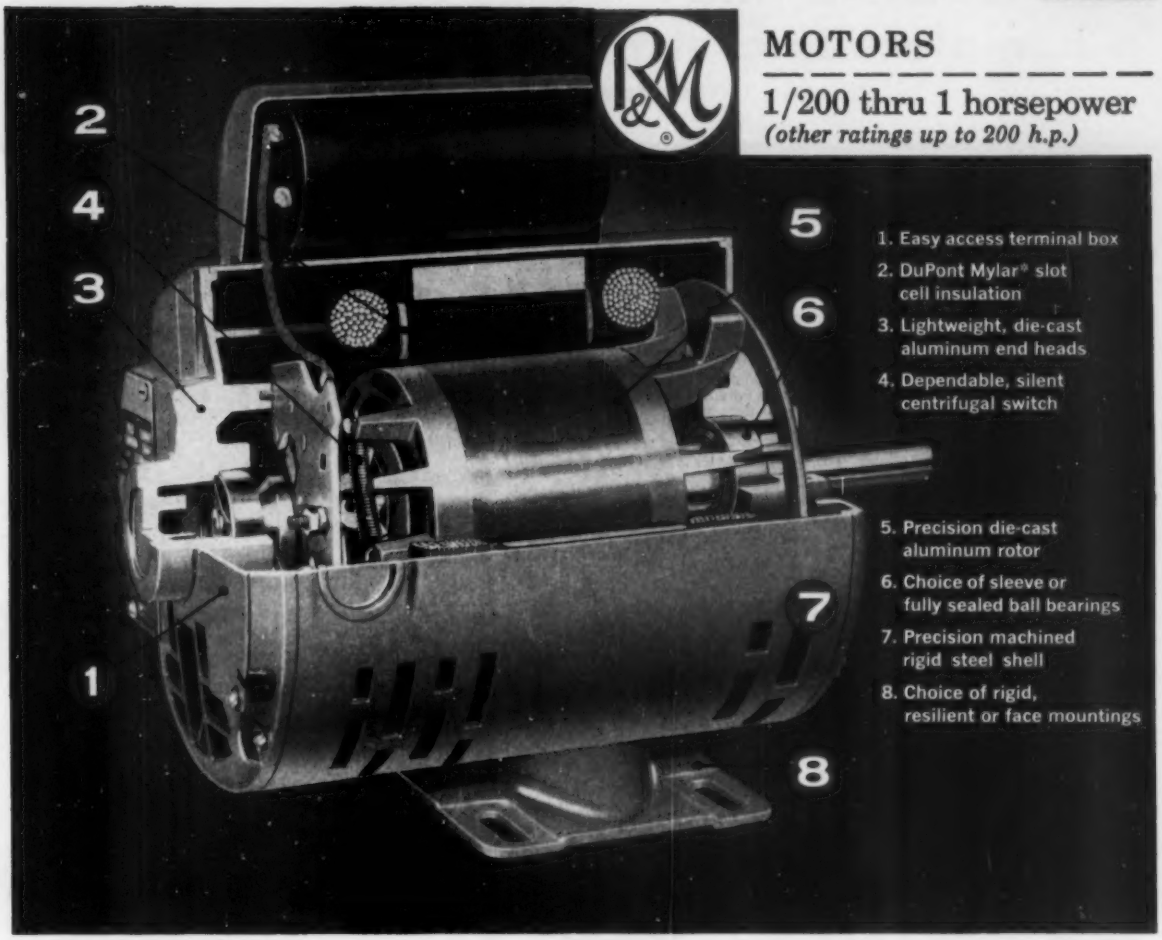
Ford Industrial Engines range from 134 to 534 cubic inches . . . including two Diesels. All are available as engine assemblies or power units, and can be fitted with Ford-approved attachments such as SAE housings, torque converters, transmissions and other equipment for special operating needs.

What's more, Ford users enjoy a minimum of downtime because there's always a Ford Dealer nearby with a complete stock of the more commonly purchased replacement parts. Yours at low Ford prices.

Get the *right* power for your application. Check Ford's full line of 4-, 6-, and V-8-cylinder engines soon.

INDUSTRIAL ENGINE DEPARTMENT • FORD Division of FORD MOTOR COMPANY
P. O. Box 598, Dearborn, Michigan

YOUR JOB IS WELL-POWERED WHEN IT'S FORD-POWERED!



R & M Fractional Horsepower Motors are packed with *Competitive Advantages* for your product!

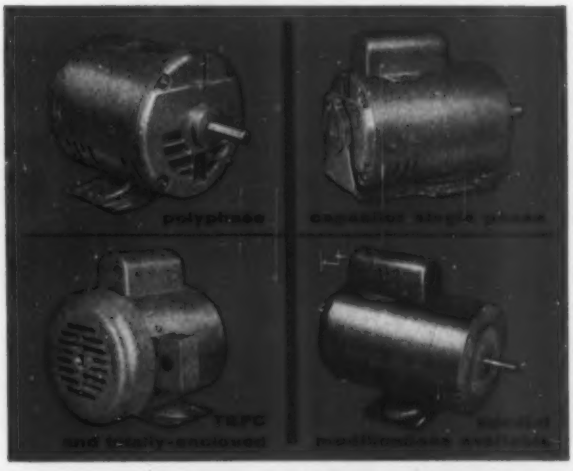
ROBBINS & MYERS "Model R" fractional HP motors, available in NEMA frames 56 and 48, are engineered and manufactured to give your product every possible competitive advantage so far as power is concerned. Each design detail results in superior performance and long trouble-free life, even under the severest operating conditions. They are smaller due to a more efficient ventilating system and lighter because of new applications of aluminum, steel and copper.

You have wider design versatility too, because they are available off-the-shelf in a broad choice of bearings, mountings, ratings, speeds and electrical characteristics.

These up-to-date design features, coupled with careful quality control at each manufacturing step, give you a modern motor you can rely on for all your powering needs. Also, if your needs indicate a custom designed motor Robbins & Myers welcomes the opportunity to discuss your quantity requirements.

Learn all about the many advantages R&M motors offer you by writing today for Bulletin 450 PRE

*DuPont registered trademark



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

WRITE 435 ON READER SERVICE CARD 435

The BODINE line—
a complete line of fractional hp motors

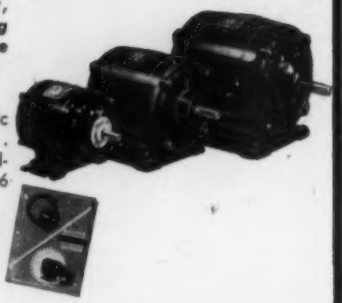
More than 3500 standard built-to-order motors

...for blowers, pumps, coin-handling units, communication equipment, therapeutic devices, sound-recording and reproducing equipment, machine tools, and similar applications

BODINE TYPE N MOTORS

These motors are available in three basic sizes... the smallest 3⅜" in diameter... the largest 5½". Almost any type winding. Standard ratings from 1/150 to 1/6 hp at 1725 rpm.

Write for bulletin "S"



...for instruments, timing devices, control apparatus, and related equipment

BODINE TYPE K-2 MOTORS

Available with and without speed reducers. Model without reducer ideal for equipment requiring relatively low output. Overall height only 2⅜". Instantly reversible. Can be stalled indefinitely. Synchronous or non-synchronous. Normal 60-cycle output ranges from 1/2000 to 1/500 hp on continuous duty.

Models with parallel shaft speed reducer have high starting torque of not less than 150% of full load torque at room temperature. Quickly reversible under load. Synchronous or non-synchronous. Drive shaft speeds range from 300 to 0.7 rpm...torque ratings from 1.3 in. oz. to 120 in. oz.

Write for bulletin 1024A
...for speed reducer models, bulletin 1023B

...for use in office machines, automatic phonographs, circulating pumps, air conditioning equipment, and similar applications

BODINE TYPE U MOTORS

"U" type motors are available in 1/20 and 1/15 hp at 1725 rpm...and in 1/30 hp at 1125 rpm. Diameter 4⅜". Split-phase construction. Resilient mounting for quiet operation. Thermal overload protection.

Write for bulletin 1028

295 different stock types and sizes ready for fast shipment!

BODINE ELECTRIC CO., 2510 W. BRADLEY PLACE, CHICAGO 18

BODINE
fractional / horsepower
MOTORS

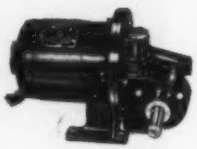
...the power behind the leading products

BODINE SPEED REDUCER MOTORS

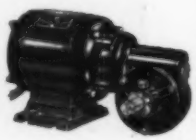
...combines motor and speed reducer in one unit, eliminating all cumbersome and complicated speed reducer transmissions such as belts, gears, and chains

...single or double reduction speed reducers for transmitting low torques over a wide range of speeds. Height, 3⅝".

...double worm-gear reducer to deliver moderate torques at low speeds. Height, 4¾".



...single reduction, right angle worm gear reducer to deliver moderate torques. Height, 4⅞".

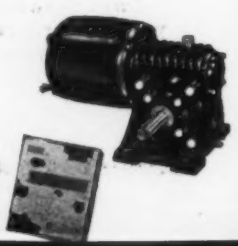


...double worm-gear reducer for transmitting high torques at low speeds. Height, 6⅞".

...single reduction, right angle worm gear reducers for transmitting substantial torques. Height, 6¼".

...heavy duty reducer for continuous driving of heavy loads. Ample reserve for overloads. Height 7⅞". Eight different windings.

Write for bulletin 1022B



AMERICAN-Standard
AMERICAN RADIATOR & STANDARD SANITARY CORPORATION

DETROIT CONTROLS DIVISION
Sales Promotion — Advertising Department
5900 Trumbull Avenue, Detroit 8, Mich.
Telephone: Trinity 2-0300

A Message To PRODUCT DESIGNERS

Are you looking for a control that is positive in action under all operating conditions?

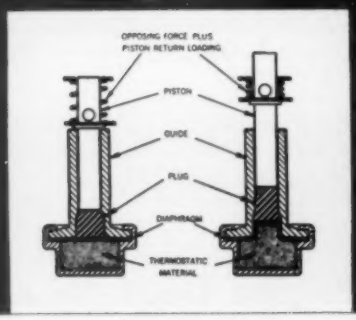
You'll find your answer in Detroit "Vernatherm"® thermostatic, high force actuators which respond only to temperature changes—cannot accidentally be activated because of vibration, system pressure variations or changes in barometric pressure.

The Detroit "Vernatherm" actuator is ideal for such applications as controlled by-pass thermostats, choke thermostats and pressure and temperature control valves, etc.

Sizes range from miniature elements capable of lifting a 30-pound load one third of an inch to king-sized units that can move a 250-pound load as much as half an inch.

Temperature control ranges all the way from sub-zero through 450°F. Detroit "Vernatherm" Controls have been used successfully in a variety of applications for more than 20 years. Typical uses include automobiles, tractors, heavy-duty engines, locomotives, ships, aircraft, rockets, missiles, heating and home laundry units.

Our engineering department is available to help adapt this unit to your product. Just write to Detroit Controls Division of American-Standard, 5900 Trumbull Avenue, Detroit 8, Mich., for Bulletin 213-A.



HOW IT WORKS

The Vernatherm actuator utilizes the activating force of special materials highly sensitive to temperature changes. As temperatures increase, the material expands and moves a piston. The movement operates disc valves, mechanical linkages or electric switches, etc. As temperatures drop, a spring causes the piston to return to its original position.

AMERICAN-Standard PRODUCTS

AMERICAN-Standard
DETROIT CONTROLS DIVISION

MOTOR, ENGINES AND CONTROLS

INDUSTRIAL ENGINES...

with 'Jeep' DEPENDABILITY!

These three hard-working engines were designed **especially** for industrial use. They have the traditional 'Jeep' toughness and reliability — plus "Keypoint Engineering" that gives the Jeep its extra stamina. The parts that do the most work are built the strongest. Just one example of the sound engineering sense that goes into Jeep engines, keeping them in their best fighting trim. The result — no weak spots to cause expensive breakdowns. All three engines have positive valve rotators and stellite or eatonite valves and valve seat inserts to insure a long life of trouble-free operation.

20-45 HP—the Jeep L-4

(continuous duty)

This 4-cylinder engine combines the smoothness of a six with the economy of a four. It's an improved and industrialized version of the engine that powered the famous Jeep in two major wars.

20-55 HP—the Jeep F-4

(continuous duty)

This is the only F-head 4-cylinder design built today — the most efficient and economical "four" available to industry. F-head design permits large intake valves for breathing qualities superior to L-head or OHV engines.

33-65 HP—the Jeep 'Six'

(continuous duty)

For jobs requiring 33-65 horsepower, this 'six' is tops . . . produces 143 ft/lbs for continuous duty at 1200 rpm, and can still deliver 132 ft/lbs for continuous duty at 2600 rpm!

THE POWER UNIT

Available with all Jeep Industrial engines, this is a complete unit from radiator to SAE bell housing. The heavy gauge housing affords complete accessibility to the enclosed engine through a hinged, divided top and removable side panels. Each Jeep power unit is operatable at the moment of delivery.

Accessories

Many available, including mechanical and velocity type governors, Murphy safety switches, Rockford PTO's and others.

Send for Complete Details on Prices, Design Details, and Power Curves

KAISER WILLYS MOTORS

WILLYS MOTORS, INC., Industrial Engine Dept., Toledo, Ohio

you put WORKHORSE POWER

into your equipment when you specify

WISCONSIN

HEAVY-DUTY *Air-Cooled*

ENGINES

Power that has to go to work and keep slugging away day after day, month after month, year after year . . . calls for something very special in the way of heavy-duty stamina and high-torque, load-lugging performance.

Or if the job simply calls for steady, ready-to-go dependability whenever power is needed, the design engineer and builder can't afford to do less than specify service-proved power units that fit both the job and the machine. Wisconsin Engines have it all!

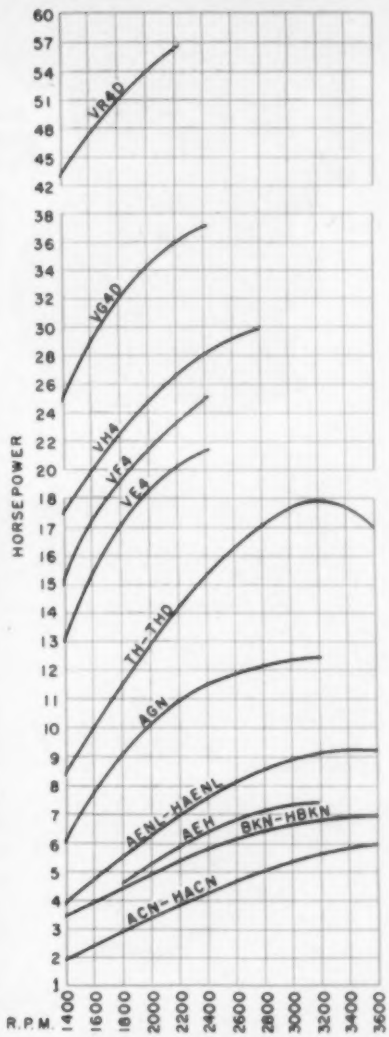
You know about Wisconsin Engines. You know that in the air-cooled field they rank Number One in aggregate total horsepower output. You know that there has never been any compromise with *Quality* in building these engines. You probably know that even the smallest Wisconsin Engines (all 4-cycle) have many of the same quality features that you find in the larger V-type models.

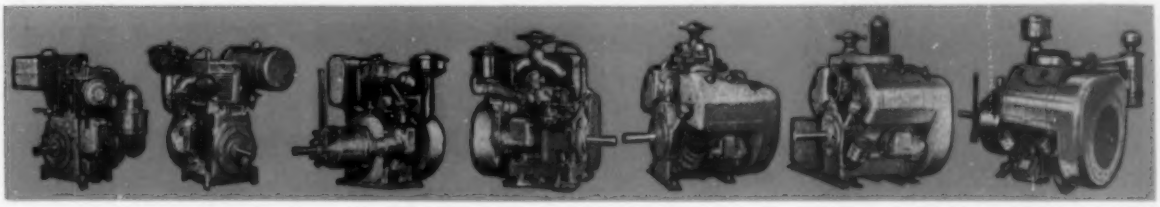
Pick your "Wisconsin" to fit the job. Your choice of a wide variety of models and sizes in a power range from 3 to 56 hp. We will help you tailor the engine to ideally fit your original equipment. Air-cooled engine compactness and light weight, without sacrificing ruggedness, are part of the package. All models can be supplied with electric starting.

Check the composite power curves shown on this page. Then write for specifications covering models in which you are interested . . . or Bulletin S-237 will give you a briefing on the full line. No obligation.

WISCONSIN MOTOR CORPORATION
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

CHECK THIS COMPOSITE POWER CURVE CHART FOR ENGINES BEST SUITED TO YOUR EQUIPMENT REQUIREMENTS.





KOHLER ENGINES

4-cycle • Short Stroke Air-cooled

Kohler engines are conservatively rated, quick-starting, reliable.

Experienced application engineers will help you choose a Kohler engine to do your job.

Kohler Co. has manufactured internal combustion engines for 38 years.

MODEL
K161

MODEL
K662

Riding Tractors
Rotary Tillers • Orchard Sprayers
Centrifugal Pumps • Weed Cutters
Highway Line Markers • Conveyors
Riding Lawn Mowers • Turf Aerators
Snow Blowers • Refrigerated Trucks

IN Action-Everywhere

Lawn Rollers • Cultivators • Grain Blowers • Milkers • Grain Elevators
Disc Grinders • Pump Jacks • Portable Saws • Sprayers • Motor Bikes
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Concrete Mixers • Vibrators • Scooters • Rail Drills
Sand Spreaders • Spike Pullers • Tie Tampers
Kohler Electric Plants

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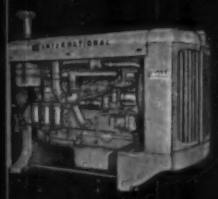
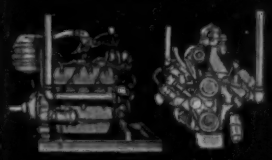


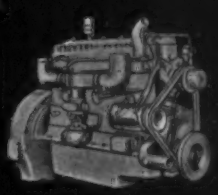
U-1091
248 max. hp. (nat. gas)

UV-549
222 max. hp.



UV-461
179 max. hp.

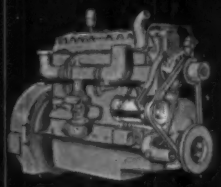
UV-401
170 max. hp.



U-501
141 max. hp.

U-450
134.5 max. hp.

UB-264
112 max. hp.



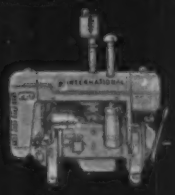
U-372
110 max. hp.

UC-263
95 max. hp.

U-308
92 max. hp.

UB-220
83 max. hp.

UC-221
75 max. hp.



UC-135
42 max. hp.

UC-60
16.5 max. hp.

Specify International and be sure your product's engine has *fastest payback power!*

You can be sure fastest payback power starts in your new product's engine when you specify International.

International engineers with over 50 years of heavy-duty engine design experience have made fastest payback power the one common feature of all of these engines through lowest cost operation, long-working stamina, thorough sealing, and minimum maintenance.

And it's easy to match International power exactly to your machines without overpowering or underpowering. Choose from models ranging from 16.5 to 385 max. hp. Choose from diesels or natural gas, LPG and gasoline carbureted models in 4's, 6's, and V-8's.

All models are available from stripped engines to complete power units. A wide variety of accessory equipment including air cleaners, flywheels for leading makes of torque converters and clutches, torque converter coolers, air compressors, safety shut-offs, instruments and engine controls can be furnished. Bases, radiators, hoods and dashes, clutches and power take-offs can be ordered for complete power units.

For additional product information or any type of installation assistance you might require, call or write International Harvester Co., Engine Sales Dept., Construction Equipment Division, Melrose Park, Ill.

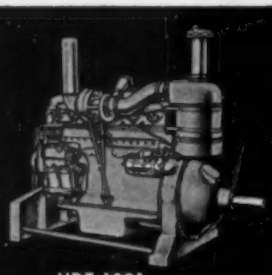
International® *Construction Equipment*

International Harvester Co., 180 North Michigan Avenue

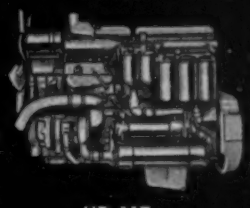
A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

DIESEL

UDT-817
375 int. hp.

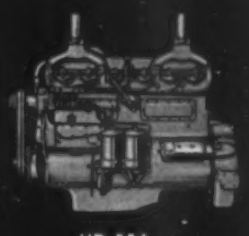


UDT-1091
265 int. hp.

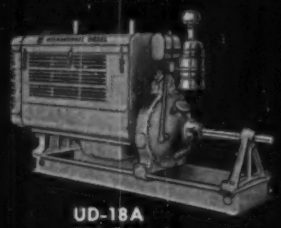


UD-817
240 int. hp.

UD-1091
216 int. hp.

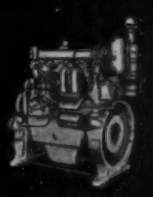


UD-554
140 int. hp.



UD-18A
131.5 int. hp.

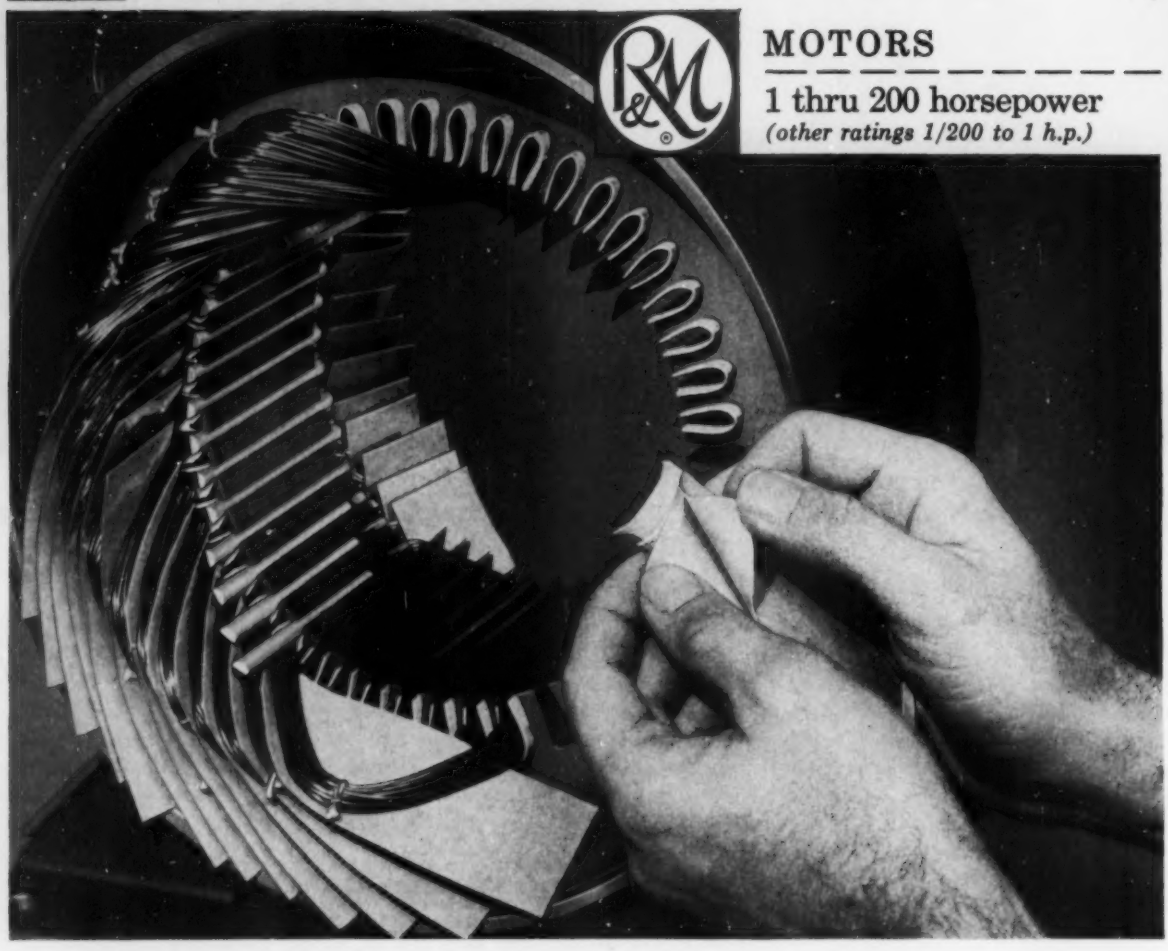
UD-14A
105 int. hp.



UD-370
95 int. hp.

UD-282
90 int. hp.

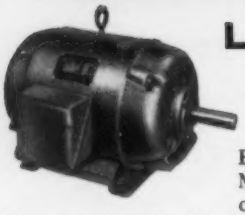
UD-236
70 int. hp.



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

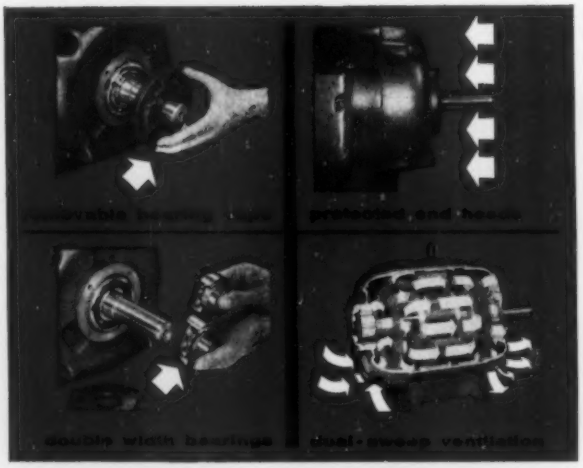


Locked-In, Laminated Insulation

Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 PRE

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

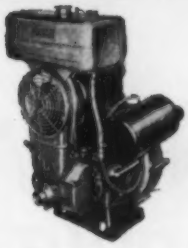
SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

DESIGN AROUND HERCULES COMPLETE LINE

AIR-COOLED DIESEL
5-7 HP

Jlo* Series 365 weighs only 110 lb. Simple, 2-cycle design saves on maintenance, provides dependable operation.

*Reg. T.M. Jlo-Werke G.m.b.H., Pinneberg, Germany.

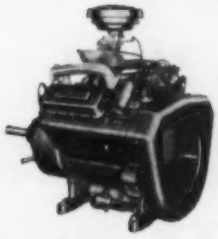


AIR-COOLED DIESEL
10-12 HP

Jlo* Series 660 weighs only 190 lbs. Ideal for portable and auxiliary power applications.

AIR-COOLED GASOLINE
30-35 HP

Hercules C2-90D engine outperforms many 4-cylinder air-cooled engines. Heavy construction assures dependability in tough service.

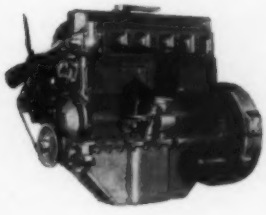


AIR-COOLED GASOLINE
65-71 HP

The Hercules CV4-180 stands alone among industrial air-cooled engines: delivers dependable responsive power for welder, pump, machinery, light vehicle drive.

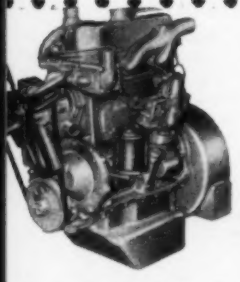
LIQUID-COOLED GASOLINE POWER UNITS
35-150 HP

Hercules makes a complete line of power units from 35 to 150 HP. Famed GO line offers many advanced features and world-famous Hercules dependability. In 3, 4, and 6 cylinder models with high degree of parts interchangeability.



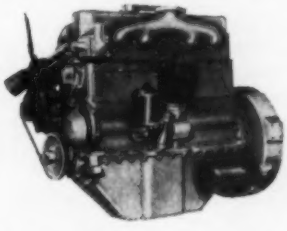
LIQUID-COOLED GASOLINE
35-150 HP

Hercules GO line of 3, 4, and 6 cylinder engines has maximum parts interchangeability: offers economical power selection in modern, overhead valve engines . . . and mounting interchangeability with DD engines in like number of cylinders.



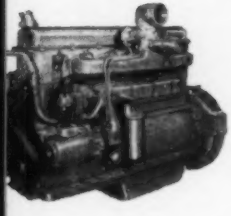
LIQUID-COOLED DIESEL
50-200 HP

Hercules DD line, in 3, 4, and 6 cylinder sizes, has complete mounting interchangeability with gasoline counterparts: simplifies OEM production procedures when alternate power plants are offered.



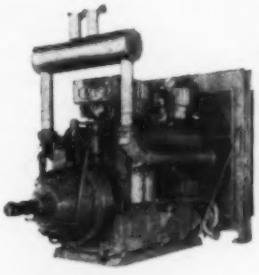
LIQUID-COOLED DIESEL
50-200 HP

Hercules DD engines can be turbo-charged for high horsepower output. The TCD-298, for example, delivers up to 200 HP for truck applications in a high-power-per-pound package unequalled by any other available today.



LIQUID-COOLED GASOLINE
200-350 HP

Hercules Hall-Scott series has a world-wide reputation as the finest truck engine made. Million-mile service from many of these engines has confirmed their excellent design. Also available as power units.



LIQUID-COOLED GASOLINE
350-575 HP

Hercules Hall-Scott Model 2269-0 is a V-12 power plant unequalled for high-power-per-pound of weight. Dependable in service, this compact engine can be trailer-mounted for mobility.

HERCULES ENGINES . . . *Sold and Serviced the World Over*

HERCULES

HERCULES MOTORS CORPORATION
Canton, Ohio

WRITE 443 ON READER SERVICE CARD

INCREASE PRODUCTIVITY WITH Wagner® QUALITY MOTORS

Boost the productivity of the equipment you design by providing motor drives that will operate dependably, with a minimum of down time for maintenance. Choose a motor that is matched to the job, with the proper speed . . . horsepower . . . voltage—that has the right enclosure for your application . . . drip-proof . . . totally-enclosed . . . explosion-proof.

Chances are, you can find the exact motor you need in the complete line of Wagner standard motors . . . a well-known, completely dependable motor with a reputation for quality. A few of the many motors in the Wagner line are shown here. Their excellent performance in their specific applications, their price and prompt delivery make them a sound choice for your equipment.

OTHER WAGNER MOTORS
In addition to the motors shown here, Wagner also furnishes Increment type motor and starter combinations, Multispeed motors, Wound rotor motors, Jet pump motors, Vertical and flange mounted motors, and Air-over motors. Consult your nearby Wagner Sales Engineer, or write for information.

¼ hp Type RK

Capacitor-start. General purpose single-phase motors that operate in any position—provide quick, trouble-free starting—pack plenty of power into little space. ⅛ through ¾ hp. Also in integral ratings through 5 hp.

50 hp. Type DP

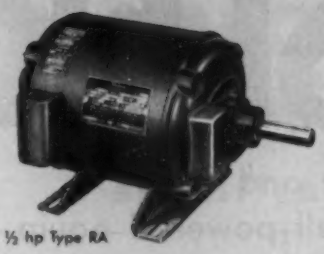
Doubly Protected (Type DP). Cast iron frames and endplates protect aaginst corrosion. Drip-proof enclosures are designed for protection against falling or splashing liquids. Sleeve or ball bearing, 1 through 125 hp.

400 hp Type ZP

Tube Ventilated. Cooler running motors for heavy duty applications—big fans, blowers, pump drives. Tube cooling system holds operating temperatures within specified limits. Standard TEFC or explosion-proof through 500 hp.

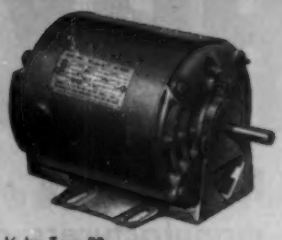
MOTOR, ENGINES AND CONTROLS

FRACTIONAL HP MOTORS



½ hp Type RA

Repulsion-start Induction. Single-phase motors that make tough starts easy. Start heavy loads with extremely low starting current—stand up under long service. ⅛ through ¾ hp. Also in integral ratings through 15 hp.



¼ hp Type RB

Split-phase. Small, light weight single-phase motors designed for low starting torque requirements. These motors can solve many application problems economically. 48 frame, ⅛, ¼, ½ hp.

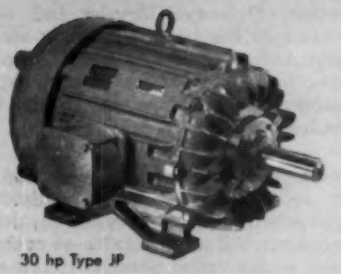
½ hp Type RP

Polyphase Squirrel-cage. General purpose, normal torque polyphase motors in fractional horsepower ratings. 56 frame motors for machine tools, pump, fans, compressors where polyphase power is used.

INTEGRAL HP MOTORS

900 hp Type RP

Open Type Polyphase Squirrel-cage. Drip-proof. Suitable for all general purpose applications. In 583 frame and larger steel frames. Sleeve or ball bearings. Ratings through 1000 hp.



30 hp Type JP

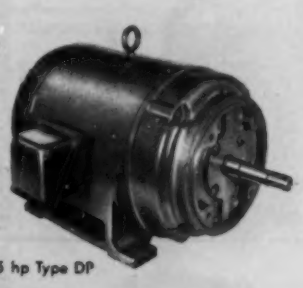
Extra Protected (Type EP). TEFC motors give complete protection against dust, abrasives, fumes or chips. Cast iron frames protect against corrosion. Also in Explosion-proof (Type JP). Ribbed frames, 1 to 100 hp, smooth frames, 125 to 250 hp.

10 hp Type RP

Extra Quiet Polyphase. Smooth running, resilient mounted motors, with sleeve or ball bearings, in ratings through 10 hp. Can be mounted on walls or ceilings, as well as in normal horizontal position.

7½ hp Integral Type

Gearmotors. These compact gearmotors have greater than usual capacity, cast iron frames and housings for corrosion resistance, are available with open-protected or TEFC motors. Integral-type or all-motor type.



25 hp Type DP

Close-coupled Pump Motors. These normal torque polyphase motors, in ratings 1 through 100 hp, are available in face mounted models with special shaft extensions, for direct connection to centrifugal pumps.

7½ hp Polyphase

Hermetic Motors. For sealed refrigeration and air conditioning units, Wagner builds hermetic motors in both single-phase and polyphase squirrel-cage types, in fractional and integral ratings to 600 hp.

WM59-15

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation

6406 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

SERVING 2 GREAT GROWTH INDUSTRIES . . . ELECTRICAL - AUTOMOTIVE

CHRYSLER

here's why more and more manufacturers of self-powered equipment are installing big output, low cost Chrysler Industrial Engines.

1 **Greater endurance:** Chrysler Industrial Engines are high-speed, heavy-duty power plants built to stand up under the toughest jobs.

2 **Greater efficiency:** Chrysler Ind. 56A, for example, has oversquare, short-stroke design that cuts friction loss to a minimum; hemispherical-design combustion chambers produce more power with less heat loss.

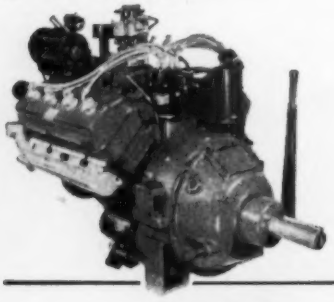
3 **Greater adaptability:** Chrysler Engines can be tailored to your individual requirements with Chrysler optional equipment. All are available as open or closed power units; operate at full efficiency on gasoline, natural or L-P gas.

OPTIONAL EQUIPMENT AVAILABLE ON CHRYSLER INDUSTRIAL ENGINES

- Chrysler Torque Converter
- Corrosion and Fungus Resistant Electrical System
- Fluid Coupling
- Heavy-Duty Over-Center Clutch and Power Takeoff
- Mechanical or Velocity Governor
- Radio Shielding (24 volt)
- 3, 4 or 5 Speed Transmission
- Propane or Natural Gas Burning Carburetors
- Heavy-Duty, Oil Bath Air Cleaner
- Safety Switches (Low Oil Pressure, High Water Temperature)

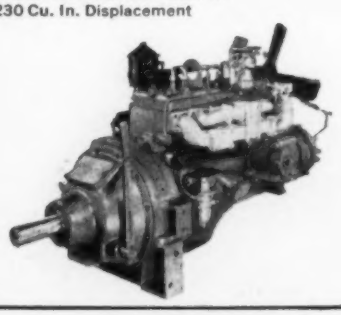
two V-8 models

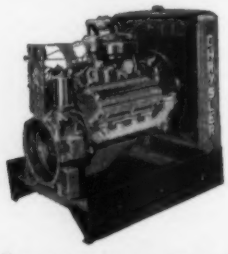
SHOWN: CHRYSLER IND. 56A
354 Cu. In. Displacement



four in-line 6 models

SHOWN: CHRYSLER IND. 31
230 Cu. In. Displacement





Chrysler open power units

Open power units for all engines include complete engine, plus skid base, fuel tank, radiator, instrument panel—complete with instruments—mounted on flywheel housing.

Chrysler enclosed power units

Enclosed power units have complete engine, fuel tank, storage battery, instruments and instrument panel, flywheel, flywheel housing, skid base and completely enclosed sheet metal.

Industrial Engines

specifications / ALL CHRYSLER INDUSTRIAL ENGINE MODELS

	Ind. 30	Ind. 31	Ind. 32	Ind. 33	Ind. 54	Ind. 56A
No. of Cylinders	6	6	6	6	8	8
Type of Engine—4 Cycle	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline	Gasoline
Bore—Inches	3¼	3¼	3⅞	3⅞	3.63	3.94
Stroke—Inches	4⅜	4⅜	4⅜	4⅜	3.80	3.62
Displacement—Cu. In.	230	230	265	265	315	354
Compression Ratio	7.0	7.0	6.8	6.8	7.5	7.5
Valves—Arrangement	L	L	L	L	Vee	Vee
Pistons—No. Rings	4	4	3	3	3	3
Crankshaft—Bearings	4	4	4	4	5	5
Camshaft Drive	Silent Chain	Gear	Silent Chain	Gear	Silent Chain	Silent Chain
Camshaft—Bearings	4	4	4	4	5	5
Crankshaft—Bearing Diameter—Inches	2½	2½	2½	2½	2½	2½
Lubrication—Type	Press.	Press.	Press.	Press.	Press.	Press.
Lubrication—Type Oil Pump	Rotor	Rotor	Rotor	Rotor	Rotor	Rotor
Lubrication—Oil Capacity Qts.	5	5	5	5	5	5
Ignition—Battery Type	Yes	Yes	Yes	Yes	Yes	Yes
Spark Plug—Size	14 mm	14 mm	14 mm	14 mm	14 mm	14 mm
Starting—Elec. Type	6 Volt	6 Volt	6 Volt	6 Volt	6 Volt	6 Volt
Gen. Reg.—Full Voltage	45 Amps.	45 Amps.	45 Amps.	45 Amps.	45 Amps.	45 Amps.
Gen. Reg.—Full Voltage and Current Control	Yes	Yes	Yes	Yes	Yes	Yes
Carburetor—Type	Down-Draft	Down-Draft	Down-Draft	Down-Draft	Down-Draft	Down-Draft
Fuel Pump	Yes	Yes	Yes	Yes	Yes	Yes
Weight—Approx. (Lbs.)	575	610	740	760	720	845
Width—Inches	23¼	23¼	23⅜	23⅜	27¹³⁄₁₆	28¹³⁄₁₆
Length—Inches	32⅞	31¹³⁄₃₂	32½	33¹¹⁄₁₆	31¹³⁄₃₂	31½
Height—Inches	34½	32²⁷⁄₃₂	32²⁵⁄₃₂	32²⁵⁄₃₂	33	34²³⁄₃₂

Specifications subject to change without notice.

performance data:

MODELS IND. 30 AND 31, IN-LINE 6 ENGINES

RPM	1200	1600	1800	2000	2400	2800	3200	3600
Dyna. BHP	43	57	64	70	81	90	96	99
Cont. BHP	35	47	52	57	66	73	—	—
Dyna. Torque	190	189	187	185	178	169	158	144
Cont. Torque	154	153	152	150	144	137	—	—
Spec. Fuel	.543	.538	.536	.534	.544	.570	.600	.649

MODELS IND. 32 AND 33, IN-LINE 6 ENGINES

RPM	1200	1600	1800	2000	2400	2800	3200	3600
Dyna. BHP	51	67	75	83	98	109	117	120
Cont. BHP	41	54	61	67	79	88	—	—
Dyna. Torque	225	221	219	218	215	205	192	175
Cont. Torque	182	179	178	177	174	166	—	—
Spec. Fuel	.541	.538	.540	.543	.555	.571	.592	.623

MODEL IND. 54, V-8 ENGINE

RPM	1200	1600	1800	2000	2400	2800	3200	3600	4000
Dyna. BHP	56	77	90	99	122	140	154	167	173
Cont. BHP	46	62	73	80	99	114	—	—	—
Dyna. Torque	246	251	259	260	266	263	253	243	227
Cont. Torque	199	203	210	211	215	213	—	—	—
Spec. Fuel	.56	.56	.57	.57	.57	.52	.51	.53	.56

MODEL IND. 56A, V-8 ENGINE

RPM	1200	1600	1800	2000	2400	2800	3200	3600	4000
Dyna. BHP	73	99	112	124	147	164	176	187	194
Cont. BHP	59	81	91	101	119	133	—	—	—
Dyna. Torque	315	326	329	331	325	312	294	274	254
Cont. Torque	254	264	266	268	264	254	—	—	—
Spec. Fuel	.555	.525	.517	.510	.505	.500	.511	.520	.540

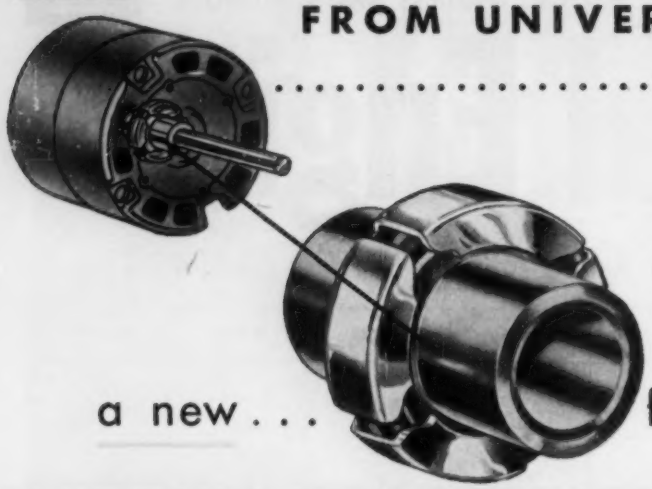
CHRYSLER INDUSTRIAL ENGINES

Industrial Engine Div.
Chrysler Corporation
Detroit 31, Mich.

WRITE 447 ON READER SERVICE CARD

MOTOR, ENGINES AND CONTROLS

FROM UNIVERSAL ELECTRIC



THE UNIVERSAL BEARING*

a new . . . free aligning bearing

*PATENT APPLIED FOR

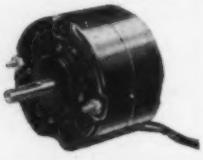
A new revolutionary bearing assembly, the **Universal Bearing**, that promises to eliminate fractional hp motor bearing problems has been designed and is now a feature of UNIVERSAL ELECTRIC motors. The new **Universal Bearing** does not rely on spring tension to aid its alignment but utilizes only the shaft itself. This is accomplished by moving the axis of support from the end of the bearing to the center . . . the ideal location.

Flexibility and rigidity of bearing support and bearing are of primary importance, particularly in fractional hp motors. The design of the **Universal Bearing** insures continuous and positive alignment to the shaft at all times. A neoprene collar, which is flexible, provides a perfect and firm fit between bearing and bearing support surface. The **Universal Bearing** is inherently in balance . . . and cannot get out of either alignment or balance. It is as firm as a rigid bearing; more flexible than a self aligning bearing.

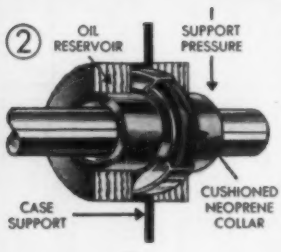
The **Universal Bearing** Assembly provides longer bearing life, better lubrication and an easier starting motor that runs without a whisper of sound. This is the first major bearing improvement since UNIVERSAL introduced the coil spring bearing retainer in 1944.

TYPE 23
1/50 to 1/12 H.P.

These are the first two UNIVERSAL ELECTRIC motors to feature the revolutionary, new **Universal Bearing.**



TYPE 118
1/200 to 1/50 H.P.



The new **Universal Bearing** is so designed that support pressure is on the center of the bearing, rather than on the end. This eliminates the uneven tension common in the spring and permits adjustment of the axis position to *true* alignment. The bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. A neoprene collar is used around the outside surface of the bearing to accommodate manufacturing tolerances. Small metal clips are fitted around the outside surface to confine the neoprene collar and allow a free sliding movement along the bearing support surface. The neoprene collar expands or contracts within the metal clips to afford a perfect mating surface.

50-A

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

448 WRITE 448 ON READER SERVICE CARD

WRITE 449 ON READER SERVICE CARD→

THE NEW

slo-syn

SYNCHRONOUS MOTORS

AUTOMATIC MACHINES AND APPARATUS
needing a simple, efficient, maintenance-free synchronous motor

NUMERICAL CONTROL SYSTEMS
requiring continuous, constant-speed traverse and/or incremental stepping for positioning

REMOTE CONTROL SYSTEMS
using either manually-operated or remote positioning control

SERVOMECHANISMS
calling for instant starting, stopping and reversing characteristics without slip or chatter

72 RPM *shaft speed*

STARTS *instantly!*

REVERSES *instantly!*

STOPS *instantly!*

can be used as a stepping motor!

THE
SUPERIOR ELECTRIC
COMPANY
Bristol, Connecticut, U.S.A.

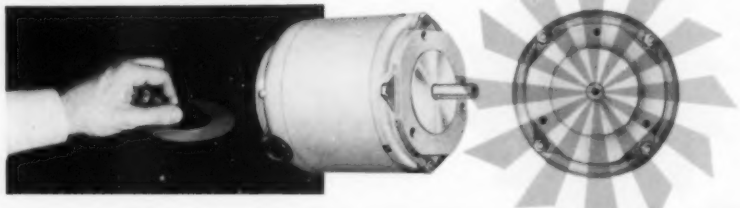
slo-syn SYNCHRONOUS MOTORS

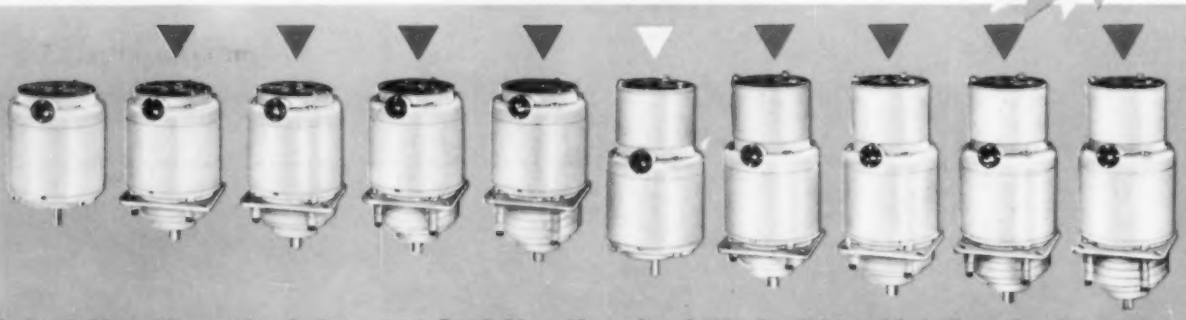
A SLO-SYN is an enclosed, permanent magnet type a-c motor with a slow basic shaft speed of 72 RPM. A single-pole, three-position switch can give complete forward, reverse and "off" control because the motor has three leads only. The SLO-SYN Motor will start or stop in less than 0.025 seconds or approximately 1.5 cycles. No need for electrical or mechanical braking because the motor will stop in less than 5° of shaft rotation. Maximum moment of inertia of a load rigidly attached to the shaft is 1.5 pound-inches². Loads with higher inertia can be started by using a coupling method which allows 5° freedom. Types having specially-designed planetary gear assemblies are available to provide speeds of 3.323, 0.665, 0.133 or 0.027 RPM. Torque on all planetary gear types is 2500 ounce-inches.

TYPE SS150

AS A D-C STEPPING MOTOR

The SLO-SYN Synchronous Motor can be adapted for use as an incremental stepping device by the use of a d-c power source and a suitable switching arrangement. When used as a control system stepping or "inching" motor, d-c electrical impulses are converted into either 200 or 400 precise increments of one revolution of the motor shaft. The motor will maintain its rated torque for any stepping position. Each step is made instantly without slip or clatter because no ratchets are used.





▼ **Available with speed reducing planetary gears**

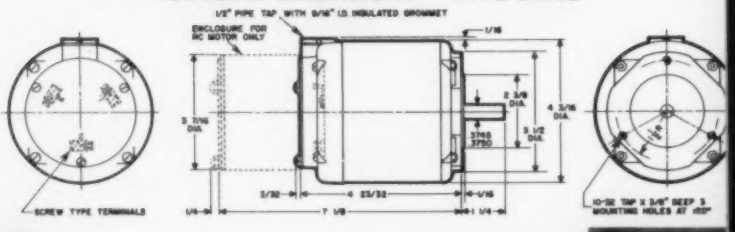
▽ **Available with enclosed capacitor and resistor**

▼ **Available with both enclosed capacitor and resistor and planetary gears**

RATINGS AND SPECIFICATIONS

INPUT	120 volts, 40/70 cycles, 1 phase
OUTPUT SPEED	72 RPM at 60 cycles
MAX. CURRENT	0.3 ampere at 60 cycles
TORQUE	150 ounce-inches
WEIGHT	6.5 pounds

OUTLINE DIMENSIONS – TYPE SS150



THE SUPERIOR ELECTRIC COMPANY, Bristol, Connecticut

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Request SLO-SYN Bulletin giving full technical information, ratings and specifications.

THE SUPERIOR ELECTRIC COMPANY

Bristol, Connecticut, U.S.A.

catalogs and bulletins.....continued

(H-64) Timing Motors—Catalog, 4 pp. Describes construction of motors; gives engineering and design details on line of clock movements, dc arnd timing motors. Hansen Mfg Co, Inc, 1959 S Hart St, Princeton, Ind.

(H-65) Special-duty Generators and Regulators—Catalog, 8 pp. Describes single and double groove GRC units and applications, also operating ranges and characteristics. American Bosch, Div of American Bosch Arma Corp, 3664 Main St, Springfield 7, Mass.

(H-66) Diesel Engines—Catalog, 8 pp. Contains specifications, drawings, and performance data on models for vehicle, marine, industrial and tractor applications. F Perkins Ltd, 60 Wingold Ave, Toronto, Ontario, Canada.

(H-67) Fractional Hp Dc Motors—Brochure, 4 pp. Contains performance characteristics, construction features an applications of line. Outline drawings photographs, ratings and dimensions. The Electric Auto-Lite Co, Champlain & Mulberry Sts, Toledo 1, Ohio.

(H-68) Motors—Brochure, 16 pp. Fractional and integral types, ½ to 800 hp. rating and dimension charts, ordering information and features are given. A O Smith Corp, 531 N 4th St, Tipp City, Ohio.

(H-69) Motors—Catalog, 7 pp. Includes types and sizes of motors manufactured, standards and specifications, mountings, enclosures and sales information. The Peerless Electric Co, Motor Div, 1401 W Market St, Warren, Ohio.

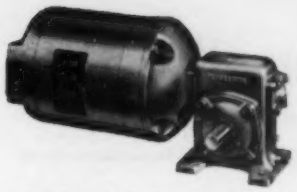
(H-70) Engines—Bulletin, 4 pp. General specifications on heavy-duty, air-cooled engines, two and four cylinders, 3 to 56 hp. Wisconsin Motor Corp, 1910 S 53rd St, Milwaukee 46, Wisconsin.

(H-71) Fans—Bulletin, 11 pp. Specifications, features and typical designs are given along with applications in electronics and aviation. Joy Mfg Co, Oliver Bldg, Pittsburgh, Pa.

(H-72) Automatic Aircraft Controls—Brochure, 12 pp. Description of facilities, examples of research and production activities in electronic and electromechanical subsystems such as computers and controls for aircraft and missile applications. Servomechanisms, Inc, 12500 Aviation Blvd, Hawthorne, Calif.

(H-73) Engines and Generators—Catalog, 4 pp. Describes and illustrates product applications of electric generating plants, air-cooled engines, separate generators and engine-compressors. Selection charts and performance data. D W Onan & Sons Inc, 2515 University Ave SE, Minneapolis 14, Minn.

(H-74) Industrial Motors—Bulletin, 12 pp. Describes motors of 1-600 hp; gives dimensions, frame sizes, weights and construction features. Brook Motor Corp, 3302-04 W Peterson Ave, Chicago 45, Illinois.



Typical Doerr-Perfection gearmotor. Offered in five sizes, in ratings from 1/20 to 1 HP. High torque capacities. Flange and vertical mountings available.

Compact 42 frame motor (only 4¾" diam.) in ratings to 1 HP.; all types and enclosures; single and dual voltage. Motor shown has both rigid face and NEMA Type C face mounting.

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Over 95% of Doerr's production consists of motors with one or more special features

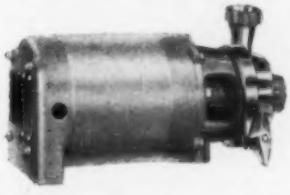
Rely on Doerr's long and specialized experience to solve your problems. List your specifications. Then let Doerr prove how easy it is to select and receive on-time delivery of motors that *exactly* fill your need.

Special features and modifications of all types are available. Present castings, windings and mountings can be adapted to solve new design problems at minimum cost. In addition, Doerr makes a complete line of standard NEMA ratings, every motor precision-built to the highest standards of quality.

Discover now why leading machinery builders consistently reorder Doerr Motors. Before you buy, just write or call us in for a talk. More than likely we can furnish the top-quality power package you want. Try us, and see.

Special diameter motor parts for use in rotary oil burners. Range ½ to 5 HP.

Doerr motor with special mounting used on leading 10" table saw.



Sanitary dairy pump motor... Doerr-Designed to customer's specifications.

Doerr motors are now offered in ratings up to 15 HP. Motor shown above is 5 HP., 215 frame, totally enclosed, fan-cooled.

Special and standard electric motors from 1/30 to 5 HP that exactly meet your needs.

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★ **Low voltage D.C. motors for battery-operated equipment**

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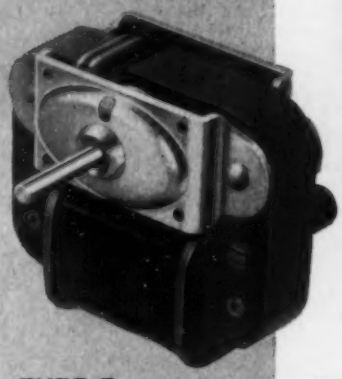
high-torque unidirectional types

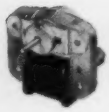
for quiet performance and long life



Outstanding for their high starting torque and low-inertia rotors, Barber-Colman motors are first choice for many of the nation's leading manufacturers. Low noise level . . . high dielectric strength coils . . . precision construction . . . compactness . . . long-life lubrication . . . and a quality guarantee backed by 30 years' experience are among the many other features of these motors that will assure long, trouble-free service in your product.

TYPE B

A high-quality motor at low cost that gives you a strong competitive advantage. Power output and starting torque exceptionally high in relation to size. Other "plus" features include alignable bearings . . . long-life lubrication . . . auxiliary oil cups . . . hardened and ground stainless steel shafts . . . ratings up to 1/200 hp.



TYPE A Ideal for use in cramped quarters. Smallest unidirectional core-type motor in the line, yet has good starting torque and power output

TYPE F Features extra high power to weight ratio while maintaining exceptionally good starting torque. Porous bronze bearings, large oil wicks.

TYPE R High-torque Barber-Colman motor for heavier power requirements up to 1/20 hp. Heavy-duty construction for the most exacting applications.

Open and enclosed geared types

for longer life at lower cost

TYPE DZ

TYPE HZ

TYPE PZ

For longest life per dollar invested put Barber-Colman geared motors into your product. High-quality construction throughout . . . accurately hobbed gears, all of which are of properly heat-treated steel (except first step Textolite gear for quieter performance) . . . high torque, positive starting.

TYPE DZ — Open-type, double-gear plate motors for applications requiring a rugged, long-life motor. Designed to handle overhanging loads. Available in unidirectional, reversible, and synchronous models.

TYPE HZ — Low-cost, rugged, compact, high-torque motors available in unidirectional, reversible, and synchronous models.

TYPE PZ — Enclosed geared construction for mounting externally to driven device. Unidirectional, synchronous, and reversible models.

FREE CATALOG HELPS SELECT MOTOR NEEDED

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catalogs and bulletins.....continued

(H-75) **Compressors**—Brochure, 8 pp. Contains principles of operation, specifications, performance ratings and applications of rotary and positive displacement compressor. Stratos, A Div of Fairchild Engine and Airplane Corp, Orinoco Drive, Bay Shore, NY.

(H-76) **Motors and Generators**—Bulletin, 16 pp. Contains an application guide for motors, drives, enclosures and mountings. Also provides dimensions, design features and ratings. Century Electric Co, 1806 Pine St, St Louis, Mo.

(H-77) **Fuel Injection Equipment**—Catalog, 4 pp. Line covers applications for diesel engines in wide hp range. Description and photographs of component parts. American Bosch Div of American Bosch Arma Corp, 3664 Main St, Springfield 7, Mass.

(H-78) **Direct-acting Brakemotors**—Bulletin, 4 pp. Charts, mountings, applications, features, characteristics and ratings of open and enclosed models. The Leland Electric Co, Div of American Machine & Foundry Co, 1501 Webster St, Dayton 1, Ohio.

(H-79) **Automatic Control Systems**—Brochure, 16 pp. Describes automatic control and communications system capabilities. Reveals engineering, design, production testing, installation techniques and facilities. Variety of typical systems for industry, public utilities and defense described and illustrated. Related components also shown. North Electric Co, 553 S Market St, Galion, Ohio.

(H-80) **Fhp Motors**—Catalog, 9 pp. Describes ac induction motors, 1/1800 to 1/35 hp; specifications, applications, drawings and ratings are included. The General Industries Co, Taylor & Olive Sts, Elyria, Ohio.

(H-81) **Miniature Converters** – Bulletin, 4 pp. Used to obtain dc power at higher voltages from standard 6, 12, or 28 v dc sources. Gives specifications, ordering information and prices in addition to schematic of typical model. Sorensen & Co, Inc, Richards Ave, S Norwalk, Conn.

(H-82) **Motor Controls and Distribution Equipment**—Catalog, 160 pp. Condensed listing of line including safety switches, bus duct, starters, pushbuttons, and others. Square D Co, 4041 N Richards St, Milwaukee, Wisc.

(H-83) **Air-cooled Gasoline Engines** – Brochure, 4 pp. Shows power curves, standard and optional equipment, applications and engineering information for design of new equipment up to 50 hp. Porsche of America Corp, 527 Madison Ave, NY 22, NY.

(H-84) **Gearmotors and Drives**—Catalog, 6 pp. Describes foot and flange mounted, single, double and triple reduction, 1 to 300 hp gearmotors. Contains selection tables and application information. Howell Electric Motor Co, 409 N Roosevelt, Howell, Mich.

catalogs and bulletins.....continued

(H-85) Integral Hp Motors—Bulletin, 8 pp. Describes features, construction details, assignments, dimensions, and general engineering information on dripproof and enclosed motors, single and polyphase, integral hp ratings, in NEMA reframed units. The Leland Electric Co, Div of American Machine & Foundry Co, 1501 Webster St, Dayton 1, Ohio.

(H-86) Diesel Engines—Bulletin, 28 pp. Description of aluminum diesel engines for construction, automotive, marine and generator service. P & H Diesel Engine Div, Harnischfeger Corp, Crystal Lake, Ill.

(H-87) General-purpose Industrial Controls—Catalog, 88 pp. Contains wiring diagrams, dimensions, specifications, hp tables, selection charts, ordering information and prices for starters, contactors, panels, relays, pilot devices, and others. General Electric Co, Bloomington, Ill.

(H-88) Air Motors—Bulletin, 8 pp. Gives dimensions, speeds, and specifications; describes features, applications, construction details. Gardner-Denver Co, Front St, Quincy, Ill.

(H-89) Air-cooled Diesel Engines—Bulletin, 4 pp. Design, construction and application fundamentals of diesels, 7 to 12 hp. Also, gives performance curves, standard and optional equipment. Hercules Motors Corp, Canton 2, Ohio.

(H-90) Controls—Bulletin, 8 pp. Describes line of switches, temperature controls, valves, and pressure controls. Gives principles of operation, ratings, curves and dimensions. Detroit Controls Div of American-Standard, 5900 Trumbull Ave, Detroit 8, Mich.

(H-91) Two-cycle Diesel Engines—Bulletin, 28 pp. Describes industrial, marine and automatic diesel engines and generator sets of extreme lightweight design, 40-330 hp. Harnischfeger Corp, Diesel Div, 500 Main St., Crystal Lake, Ill.

(H-92) Automatic Control Equipment—Catalog, 64 pp. Gives list prices, dimensions and electrical data for timing and magnetic control devices. Zenith Electric Co, 152 W Walton St, Chicago, Ill.

(H-93) Synchronous Motors—Catalog, 4 pp. Gives dimensions, output speeds, weights and sales data in addition to heavy duty continuous timing applications. Hurst Tool & Mfg Co Inc, Princeton, Ind.

(H-94) Fhp Motors—Catalog, 17 pp. Contains ordering and service information, dimensional drawings and tolerances for typical gear and governor motors, and others. Carter Motor Co, 2711 W George St, Chicago 18, Ill.

(H-95) Motor Design—Catalog, 8 pp. Line of squirrel cage, fluid-shaft, slip ring, crane-hoist, machine tool, torque, pump, and other motors designed to meet NEMA dimensional and electrical standards. Reuland Electric Co, Alhambra, Calif.

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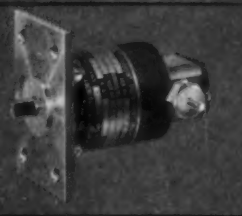
precision d-c motors

Small, high-quality d-c motors for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . permanent magnet and split series types . . . various mountings and speeds. Offered with gearheads or blowers. Radio noise filters available.

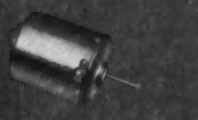
a-c 400 cycle motors

Precision missile and aircraft a-c motors designed to MIL-M-7969a. The capacitor type, four-pole motor features a balanced winding permitting reversal with an SPDT switch. A 400-cycle brake is available. Typical rating is .020 horsepower at 9700 rpm and 83 watts input, intermittent duty.



tach generators

For accurate speed indication and servo rate control applications. Supply up to 40 volts per 1,000 rpm within plus or minus 0.5% linearity. Standard temperature range is −65° to +200°F, but units have been made for −65° to +500°F ambient.



low-cost d-c motors

High-quality, compact governed d-c motor is available in speeds from 1200 to 6000 rpm. Voltages from 3 to 30 volts d-c. Suited for many battery-operated applications such as: drive mechanisms in photographic equipment, marine navigation equipment, portable dictating machines, signal-seeking radios, tape players, and portable instruments.

polarized d-c relays

Ultra-sensitive polarized d-c relays capable of operating on input powers *as low as 40* microwatts. Available with three types of adjustment: null-seeking . . . symmetrical magnetic-latching . . . or conventional form C snap-acting. Can also be supplied with integral transistor preamplifiers.

resonant relays

Characterized especially by low operating power and narrow band width. Coil impedance is high enough to be operated in the plate circuit of a vacuum tube without impedance matching devices. Can be supplied tuned to any frequency between 115 and 400 cps.

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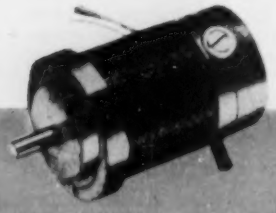
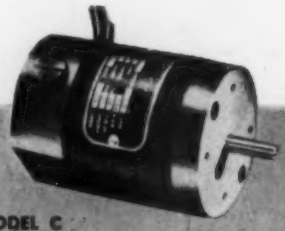
Howard alone offers such an all-inclusive line of Universal and D.C. motors—including over 65,000 specs on file for every conceivable application. With this vast source to draw from chances are there are specs on hand to meet your requirements. That's why Howard can provide the motor you need, more quickly and at lower cost. Shown here are just a few of the standard models in the Howard line. For complete information, samples and prices on these or other Howard Universal and D.C. motors—from 1/200th to 1 H.P.—send us your specifications today.

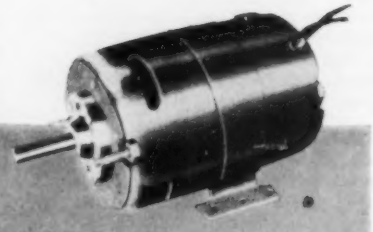
1/200th TO 1 H.P.— High Speed, High Starting Torque



MODEL B
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 1-11/16
LENGTH: 2-3/16 to 3-11/16
H.P.: Continuous 1/40
Intermittent 1/20
Full Load Speed—Series 5200 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.



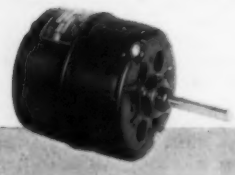
MODEL C
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 2-1/4
LENGTH: 2-9/16 to 3-9/16
H.P.: Continuous 1/25
Intermittent 1/12
Full Load Speed—Series 5200 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.



MODEL F
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-1/2
LENGTH: 4-1/8 to 5-11/32
H.P.: Continuous 1/2
Intermittent 3/4
Full Load Speed—Series 3800 to 10,000 R.P.M.
Shunt — 1800 to 10,000 R.P.M.
VOLTAGES: Series — 6 to 115V, AC-DC
Shunt — 6 to 120V DC
BEARINGS: Precision grease sealed ball bearings.

MODEL 243
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-17/32.
LENGTH: 3-15/16.
H.P.: Continuous Series—1/12 @ 10,000 R.P.M.
Intermittent—1/8 @ 10,000 R.P.M.
SPEED: Full Load Speed:
Series—3000 to 10,000 R.P.M.
Shunt—2000 to 7000 R.P.M.
VOLTAGES: Series—12 to 230V. AC/DC.
Shunt 6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with oil reservoir.

MODEL 29-500
TYPE: Universal AC/DC or Shunt.
DIAMETER: 3-3/16.
LENGTH: 4-11/16 to 5-19/32.
H.P.: Continuous: Series—1/6 @ 10,000 R.P.M.
Shunt or Compound—1/12
Intermittent Series—1/4 @ 10,000 R.P.M.
Shunt or Compound—1/6.
SPEED: No Load: Series—15,000 R.P.M.
Shunt or Compound—12,000 R.P.M.
Full Load Speed: Series—3000 to 10,000 R.P.M.
Shunt or Compound—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 250V. AC/DC.
Shunt or Compound—6 to 230V. DC.
BEARINGS: Porous bronze sleeve type or grease sealed ball bearings.

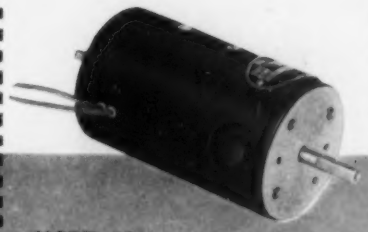


MODEL 11A
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2.825".
LENGTH: 3-9/16".
H.P.: Continuous 1/75.
Intermittent: 1/20.
SPEED: No Load Speed: Series — 15,000 R.P.M.
Shunt — 3580 to 12,000 R.P.M.
Full Load Speed: Series — 3000 to 10,000 R.P.M.
Shunt — 2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC-DC.
Shunt — 6 to 120V. D.C.
BEARINGS: Porous bronze self aligning type with felt oil reservoir.

454 WRITE 454 ON READER SERVICE CARD

COMPLETE LINE OF UNIVERSAL & DC FRACTIONAL H.P. MOTORS

MODEL 11-12
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-25/32". 2-9/32" flat side.
LENGTH: 4-19/32".
H.P.: Continuous Series—1/15 @ 10,000 R.P.M.
Shunt—1/20.
Intermittent: Series—1/6 @ 10,000 R.P.M.
Shunt—1/8.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—3500 to 10,000 R.P.M.
Full Load: Series—5000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze self aligning type with felt oil reservoir, or grease sealed ball.



MODEL 106
TYPE: Series or Shunt DC only.
Diameter: 2-5/16".
LENGTH: 3.99".
3.85".
H.P.: Continuous: Series—1/35 @ 10,000 R.P.M.
Intermittent: Series—1/10 @ 10,000 R.P.M.
Shunt—1/10.
SPEED: Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—1800 to 10,000 R.P.M.
VOLTAGES: Series—6 to 120V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 200
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 1-11/16".
LENGTH: 2-11/16".
H.P.: Continuous Series—1/200 @ 10,000 R.P.M.
Shunt—1/200.
Intermittent: Series—1/75 @ 10,000 R.P.M.
Shunt—1/75.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—15,000 R.P.M.
Full Load Speed: Series—5000 to 10,000 R.P.M.
Shunt—3000 to 10,000 R.P.M.
VOLTAGES: Series—6-115V. AC/DC.
Shunt—6 to 32V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 512
TYPE: Universal AC/DC or DC Shunt
DIAMETER: 3-3/8". LENGTH: 4-3/4".
H.P.: Continuous Series—1/10 @ 10,000 R.P.M.
Shunt—1/12.
Intermittent: Series—1/5 @ 10,000 R.P.M.
Shunt—1/6.
SPEED: No Load Speed: Series—15,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: 5000 to 10,000 R.P.M.
Shunt: 1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type.

MODEL 700
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 3.900".
LENGTH: 3-7/64". to 6-7/64".
H.P.: Continuous: Series—1/4 @ 10,000 R.P.M.
Shunt—1/8.
Intermittent: Series—1/2 @ 10,000 R.P.M.
Shunt—1/4.
SPEED: No Load Speed: Series—18,000 R.P.M.
Shunt—2000 to 12,000 R.P.M.
Full Load Speed: Series—5000 to 10,000
Shunt—1000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 115V. AC/DC.
Shunt—6 to 230V. DC.
BEARINGS: Grease sealed ball bearings.

MODEL 1100
TYPE: Universal AC/DC or DC Shunt.
DIAMETER: 2-13/16". LENGTH: 3-9/16".
H.P.: Continuous: Series—1/50 @ 10,000 R.P.M.
Shunt—1/50.
Intermittent: Series—1/15 @ 10,000 R.P.M.
Shunt—1/15.
SPEED: No Load: Series—15,000 R.P.M. approx.
Shunt—3500 to 12,000 R.P.M.
Full Load: Series—3000 to 10,000 R.P.M.
Shunt—2000 to 10,000 R.P.M.
VOLTAGES: Series—6 to 230V. AC/DC.
Shunt—6 to 120V. DC.
BEARINGS: Porous bronze sleeve type, or Grease Sealed Ball Bearings.

POWERED BY HOWARD

HOWARD INDUSTRIES, INC., 1750 State St., Racine, Wis., Telephone ME 2-2731, Teletype: RAC344

Sales Offices:
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Chicago 4, Ill., 208 S. LaSalle St., CE 6-5126
Cincinnati 2, O., 1077 Celestial St., PA 1-2985
Festus, Mo., 1049 Front Street, YE 7-3606
Los Angeles 36, 942 S. La Brea Ave., WE 8-2444
New York 1, Empire State Bldg., LO 4-7992
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CYCLOHM MOTOR CORPORATION · LS LOYD SCRUGGS COMPANY

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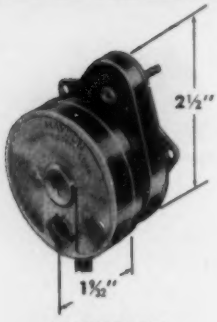
Haydon AT TORRINGTON

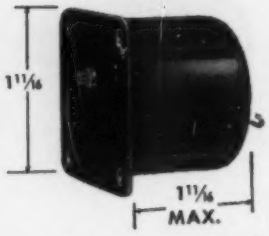
electric timing motors

Haydon totally enclosed timing motors are compact, rugged and dependable. Slow rotor speed assures quiet operation and long life. Lubrication meets various temperature requirements. Designed and engineered for all-position operation, Haydon Timing Motors mount alike regardless of series or speed. Finishes and construction to meet your specifications. One-way or two-way frictions available in both right and left rotations. Full details will be found in Haydon's complete new Timing Catalog.



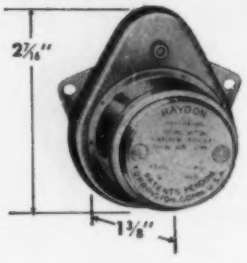
HYSTERESIS

Silent, dependable, synchronous motors now available in two torque ranges. Series MA26 with a guaranteed rating of 6 ounce-inches at 1 rpm and 60 cps, and Series MA23 with a guaranteed rating of 10 ounce-inches at 1 rpm and 60 cps. Speeds 1/60 rpm to 60 rpm. Voltages: 120 or 240, 50 or 60 cps.



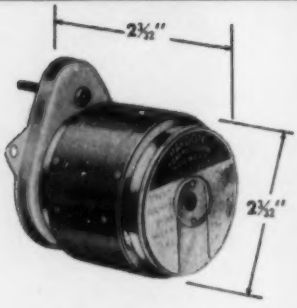
400 CYCLE (Miniature)

Small compact split phase 400 cps synchronous motor for instrumentation in military equipment. Sealed in steel case, eliminates stray magnetic fields. Speed: 3000 rpm. Voltage: 115V nominal, 400 cps.



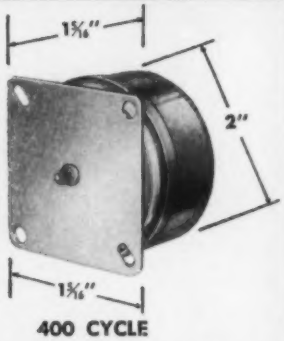
INDUCTOR

Compact and fast-starting with the extra power and ruggedness needed for dependable, heavy-duty operation. Ideal for high torque applications. **Guaranteed torque:** 30 ounce-inches at 1 rpm and 60 cps. Speeds: 1, 2, 4, 6, 8, 10, 15, 20, 30 and 60 rpm. Voltages: 120 or 240, 50 or 60 cps.



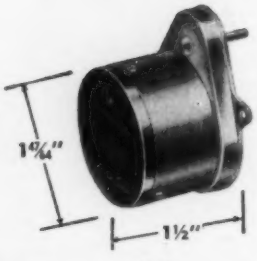
REVERSIBLE

Incorporates 2 coils. Each coil, when energized, produces opposite rotation of the output shaft. Speeds: 1/60, 1/45, 1/30, 1/15, 1/10, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 4, 6, 8, 10, 15, 20, 30 and 60 rpm. **Guaranteed torque:** 9 ounce-inches start and run to synchronism at 1 rpm and 60 cps. Voltages: 120 or 240, 50 or 60 cps.



400 CYCLE

Low-cost, split-phase capacitor motors provide the inherently accurate approach to timing control for military applications. Speed: 3000 rpm at 400 cps. Heavy Duty with 18 gram-millimeters torque. Voltage: 115 (nominal).



D-C

Permanent magnet motor with extremely low current drain. Speeds: 1/15, 1/10, 1/6, 1/5, 1/4, 1/3, 1/2, 1, 2, 4, 6, 8, 15, 20, 30 and 60 rpm; others available. Gear Train Rating: 40 ounce-inches, static load. Speed varies directly with temperature and voltage, inversely with load. Voltages: 6 to 28 d-c. R. F. Filter available — 1½" dimension increases to 1⁵⁵⁄₆₄".

When ordering motors, please specify: Speed (at no load or under load), voltage, duty cycle, shaft, friction if desired, and speed tolerance under the following conditions: voltage range, ambient temperature range, and load pattern.

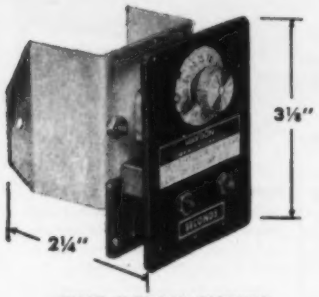
Haydon AT TORRINGTON TIMIN

DIVISION OF
GENERAL TIME CORPORATION

Haydon
AT TORRINGTON

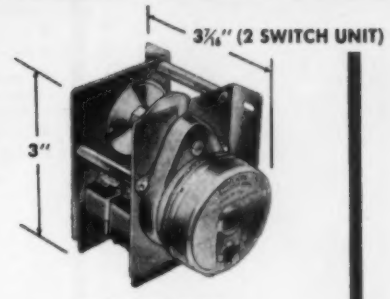
electric timing devices

The basic element of all Haydon Timing Devices is our own rugged timing motor. All Haydon Timing Devices provide long-lived, reliable, quiet service. The Haydon Timers illustrated below are ideal for a wide range of applications. Complete details will be found in Haydon's new Timing Catalog. Variations of the standard models and custom-engineered units are available. Our field engineers will be pleased to study your requirements and submit proposed designs.



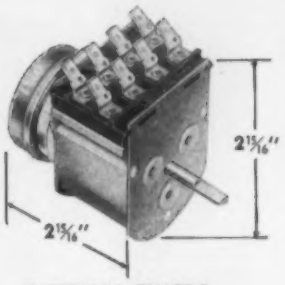
TIME DELAY TIMERS

Rugged, dependable enclosed-switch reset timer provides time delay.
Delay Ranges: 0-14 seconds
0-57 minutes
0-4.5 minutes
Switch Rating: SPDT, 20 amps, 125 VAC, or 250, non-inductive.
Motor Voltages: 120 or 240V, 50 or 60 cps.



CYCLE TIMERS

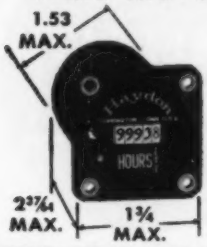
Up to 8 enclosed switches can be supplied in this direct-driven repeat cycle timer. Adjustable cams standard; blank or special available. Wide range of speeds.
Switch Rating: SPDT, various type switches available.
Voltages: 120 or 240V, 50 or 60 cps.



INTERVAL TIMERS

Directly control heavy duty electrical loads. Type AD has up to 4 SPST switches. Type AT has 1 SPST switch only. Several intervals available with or without dial and knob. Voltages: 120 or 240V, 50 or 60 cps. Switch Rating: 28 amps, 250 VAC non-inductive; 1 hp, 250 VAC.

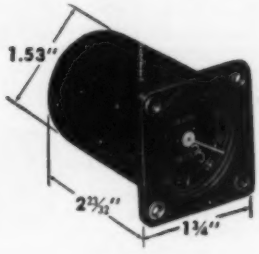
COMMERCIAL ELAPSED TIME METER



SERIES ED-71 and ED-72

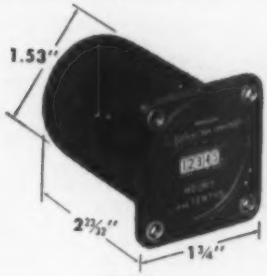
Compact low-cost units. Case is dust-tight easily mounted. ED-71 has leads 11" ±¼". ED-72 has glass fused terminals. Direct reading indicator registers hours and tenths up to 9999.9.
Voltages: 120 and 240 VAC, 60 cps 115 VAC, 400 cps.
Power Required: 2.5 watts nominal
Operating Temperature: —25°C to +65°C ambient.

MILITARY ELAPSED TIME METERS



7008

Miniature elapsed time meter, hermetically sealed.
Time Range: 10,000 hours.
Voltage: 115V, 60 or 400 cps.
Watts Input: 2.5 W. nominal at 115V, 60 and 400 cps.
Weight: 6 ounces.



7010

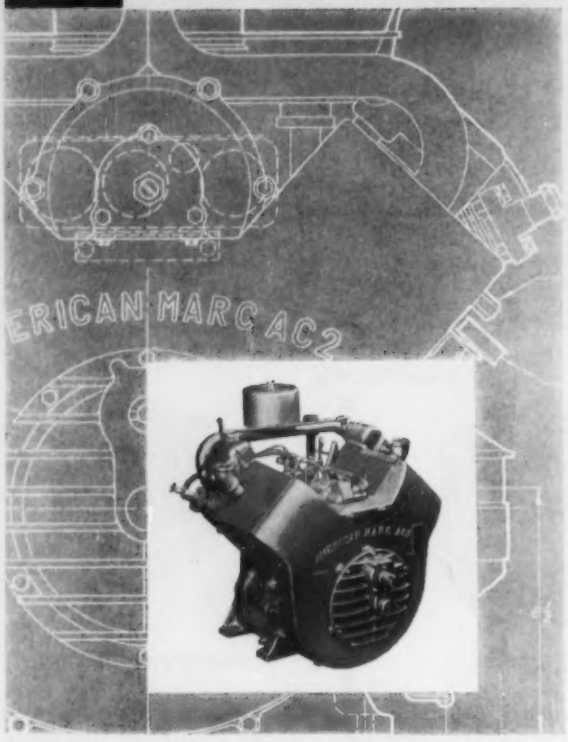
Direct reading version of the 7008 series.
Time Range: 9,999.9 hours.
Voltage: 115V, 60 or 400 cps.
Watts Input: 2.5 W. nominal at 115V, 60 and 400 cps.
Weight: 6 ounces.

MOTORS AND DEVICES

DEPT. PEDD, 245 EAST ELM STREET
TORRINGTON, CONNECTICUT
HUNTER 9-3158

When ordering timers, please specify: *Model number, voltage, frequency, ambient temperature range, intervals and switch loads (Interval Timers), number of circuits and loads to be controlled, and sequence and cycle for each circuit (Repeat Cycle Timers).*

MOTOR, ENGINES AND CONTROLS



The American MARC blueprint for **PRECISE POWER**

American MARC offers the design engineer a wide range of precision-built **PRECISE POWER** equipment from which to choose—manufactured for strict adherence to operating specifications—designed for a dependable flow of continuous power under all operating conditions. Fully guaranteed, all-American built American MARC products include:

Super rugged ultra-lightweight Diesel and natural gas engines, 10 to 20 HP, air and water cooled, for an almost infinite variety of low horsepower applications . . . **PRECISE POWER** engineering holds engine RPM to 3% maximum variation, assuring unwavering output regardless of varying load conditions.

Custom built generators, ranging from 500 watts to 100 KW, in static excited and permanent magnet types, available in AC, DC, 400 and 60 cycle models.

Generator sets, incorporating field-proven American MARC Diesels, from 2½ to 7½ KW for every electric power requirement. Engineered for **PRECISE POWER**, American MARC generator equipment features voltage and frequency regulation control to values of less than ¼ of 1%, keeping transient disturbances to a minimum in both duration and magnitude. Superb production craftsmanship assures operating dependability.

Our nation's Armed Services, demanding the ultimate in dependability, have standardized on American MARC **PRECISE POWER** Diesel equipment . . . equipment now available to you for your design applications. Our nationwide network of distributors assures you prompt service and parts dependability.

Write for complete catalog and prices, today.

Manufacturers of Natural Gas Engines, Diesel Engines, Generators and Generator Sets.

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GEARMOTORS

5 Basic Sizes

- Speed up to 200 RPM
- Power up to 40 in. lb.
- Open or enclosed case
- Continuous or intermittent
- Machine cut gears
- Finish ground shafts
- Millions in use
- Prompt delivery
- Special features available
- Samples at once
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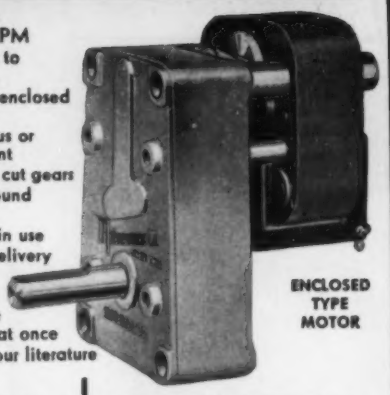

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Millions of Motoresearch Gearmotors now in use!

Motoresearch also designs and produces high frequency motors, generators, rectifier type power supplies and other Special Electrical Equipment. We invite your inquiries.

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MOTOR, ENGINES AND CONTROLS

catalogs and bulletins.....continued

(H-96) Motors and Blowers—Catalog, 16 pp. Describes general operating characteristics and applications; gives engineering information and hp outputs. Heinze Electric Co, 685 Lawrence St, Lowell, Mass.

(H-97) Generators—Bulletin, 8 pp. Describes typical applications, ratings, specifications, engineering and construction features. Gives rating and dimension charts on two-bearing and quill shaft mounted, ac and dc generators. The Leland Electric Co, Div of American Machine & Foundry Co, 1501 Webster St, Dayton 1, Ohio.

(H-98) Combination Motor Starters—Catalog, 8 pp. Describes application and features of combination motor starters, NEMA size 0 thru 6. Federal Pacific Electric Co, 50 Paris St, Newark 1, NJ.

(H-99) Diesel Engine Exhaust Hose—Bulletin, 6 pp. Includes drawings and photographs of typical installations, diameters, bend radius, lengths, lateral movement, expansion and contraction figures. Also, ordering information, application data and installation suggestions. Allied Metal Hose Co, 3746 Ninth St, Long Island City 1, NY.

(H-100) Motors—Catalog, 146 pp. Detailed construction features, mounting information, and dimensions of motors up to 1000 hp. Fractional and integral hp models, single and polyphase. Wagner Electric Corp, 6400 Plymouth Ave, St Louis 33, Mo.

(H-101) Wound Field and Permanent Magnet Motors—Bulletin, 4 pp. Describes sizes and types of universal and split series, shunt wound and permanent magnet, miniature precision motors, to 1/20 hp. Globe Industries, Inc, 1784 Stanley Ave, Dayton 4, Ohio.

(H-102) Overheat Protectors and Motor Starting Relays—Catalog, 46 pp. Gives general and technical information on built-in overheat protectors for single and three phase motors. Construction features, operational data and applications are included. Metals & Controls Corp, Spencer Div, 34 Forest St, Attleboro, Mass.

(H-103) Two- and Four-stroke Cycle Engines—Bulletin, 84 pp. Specification sheets describing various models; power data, dimensions, standard and optional equipment, and application drawings. Power Products Div, Tecumseh Corp, Clifton, Wisc.

(H-104) Packaged Liquid Rocket Engines—Brochure, 12 pp. Describes development, applications, characteristics and future potential of packaged liquid rocket engines for missiles. Reaction Motors Div, Thiokol Chemical Corp, Denville, NJ.

(H-105) Timing Controls—Catalog, 40 pp. Describes various timing devices with performance charts on each installation data, price listing. Industrial Timer Corp, 1407 McCarter Hgwy, Newark 4, NJ.

New Carter Classic
UNIVERSAL AC/DC Motor

. . . from the NEW Source of fine specialty Motors
. . . CARTER . . . with a background of over
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Totally NEW . . . and engineered to the highest standards of mechanical and electrical excellence . . . the CARTER CLASSIC FHP motor incorporates all the advances in materials and manufacturing techniques developed in recent years.

PRECISION DIE CAST CONSTRUCTION

Armature, frame and brackets . . . in fact every component has been expertly created to provide a totally NEW quality motor, not a composite of existing parts or old design. Super-precision, sealed ball bearings, no lubrication necessary.

Larger brushes provide performance beyond normal requirements, reduce maintenance. Standard mounting plate can be furnished. Speed governor available.

8 NEW MODELS TO CHOOSE FROM

H.P.	1/35	1/25	1/20	1/15	1/20	1/18	1/12	1/10
R.P.M.	3600	5000	7500	10000	3600	5000	7500	10000

Overall size 4½" x 3⅝" x 3⅜" high. Weight 3¾ lbs.

Available as universal, shunt or series motors from 12v. to 220v. input.

The CLASSIC is produced in the sparkling new Carter factory, designed expressly for efficient, economical motor production and is backed by more than a quarter century motor building experience. Fast delivery, personal attention, complete engineering service. Standard models modified to your application.

You can rely on this dependable new motor source to power YOUR products. A line so distinctive, so superior, you too will say "It's CLASSIC". Low cost will surprise you . . . pleasantly.

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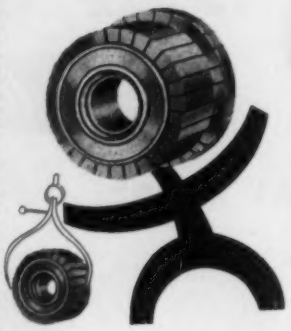
ALWAYS SPECIFY TOLEDO COMMUTATORS and COLLECTOR RINGS for top quality and prompt delivery



Always specify TOLEDO for top quality commutators and collector rings. Quality control . . . top workmanship . . . combined with the highest quality raw materials . . . are your assurance that each commutator . . . each collector ring . . . is produced to the highest standards of uniform excellence. Call Toledo Commutator Co. for quality commutators and collector rings . . . delivered quickly to your plant to save you time . . . to save you money. Write today for Catalog No. 65.

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USE ARENS STANDARD-DESIGNS

See us first . . . and you will probably find the control you are looking for. Save the time and expense of having a special remote control designed, because one of Arens' 44 (and growing all the time) standard-designs will probably fulfill your requirements. But if not, our engineering and research department will be pleased to work with you on special controls for your application. Write us your requirements.

For information on illustrated models, please circle readers' service number.

ARENS CONTROLS, INC.

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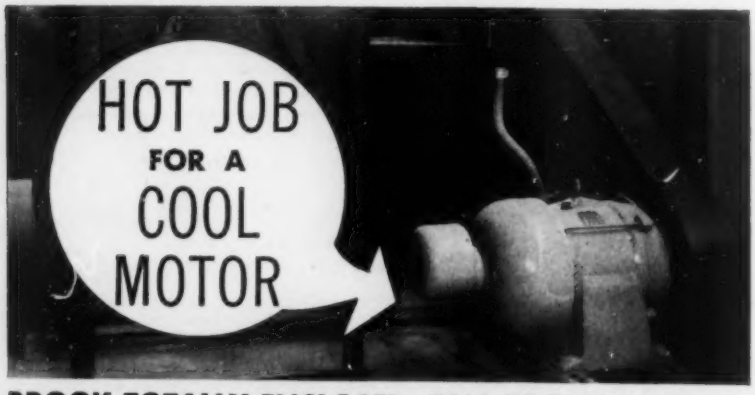

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An ideal application for this 30 HP Brook Totally Enclosed, Fan Cooled, Slip Ring Motor—built to resist heat or cold, dust, fumes, moisture. It is driving an induced draft fan handling washed flue gas and raw air at 350°F. in an American Incinerator Corp. system processing municipal waste. Brook A.C. Motors are winning praise in every industry for dependable service and overall economy. They can save for you! Warehouses, Sales Representatives, Dealers throughout the country. Send for literature.

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Companies are still canvassing colleges like crazy for bright young engineers and technologists . . .

But what about the man with ten or more years invested in his company? Here he is, ready to take on heavier responsibility. How much longer must he wait?

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Men who read more . . . earn more!

catalogs and bulletins.....continued

(H-106) Servo Motors, Tachometers and Blowers—Catalog, 80 pp. Servo motors and generators, blowers, drive motors and miniature precision units from .750 in. diameter to 6 in. diameter. Eastern Air Devices Inc, Subsidiary of Norbute Corp, 385 Central Ave, Dover, NH.

(H-107) Worm Gearmotors—Bulletin, 24 pp. Gives construction features, hp ratings, output speeds and dimensions of heat treated aluminum alloy gearmotors. Electra Motors, Inc, 1110 N Lemon, Anaheim, Calif.

(H-108) Gas Turbine Engines—Brochure, 22 pp. Includes information on development and production facilities, principles of operation, mechanical specifications, performance tests, ratings and applications Solar Aircraft Co, 2200 Pacific Highway, San Diego, Calif.

(H-109) Direction and Zero Indicating Contactors—Catalog, 32 pp. Shaft driven devices which combine hydraulic and magnetic action to control electrical circuits in relation to shaft speeds. Used on applications requiring electrical controls generally referred to as: zero speed switches, rotary motion indicators, plugging and centrifugal switches. Winterburn Mfg Co, Putnam, Conn.

(H-110) Cam Timers—Catalog, 16 pp. Includes features, dimensions, timer and optional equipment of time cycle controllers. Illustrations and ordering instructions. Electric Switch Corp, PO Box 41037, Indianapolis, Ind.

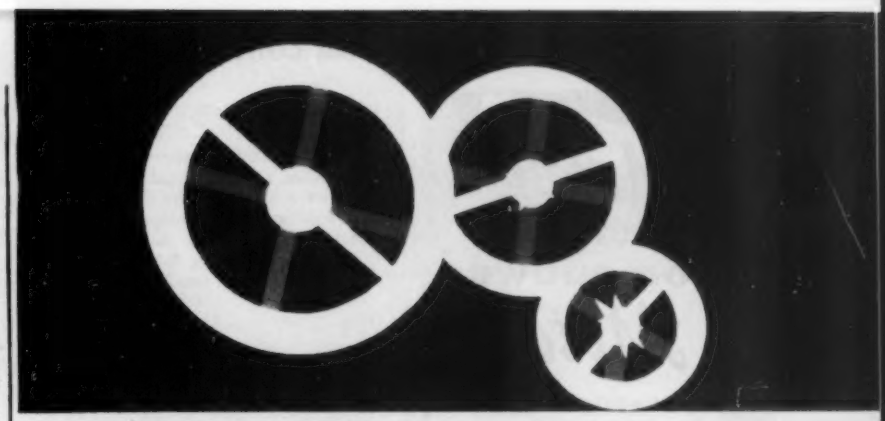
(H-111) Diesel Engines—Bulletin, 4 pp. Describes 3, 4, and 6 cylinder engines from 16 to 138 hp available as engines or self-contained power units. Hercules Motors Corp, 101 11th St SE, Canton 2, Ohio.

(H-112) Four-cylinder Industrial Engines—Brochure, 4 pp. Torque and hp curves, dimensional drawings, power unit description and accessories are covered. Willys Motors, Inc, Industrial Sales Div 940 N Cove Blvd. Toledo 1, Ohio.

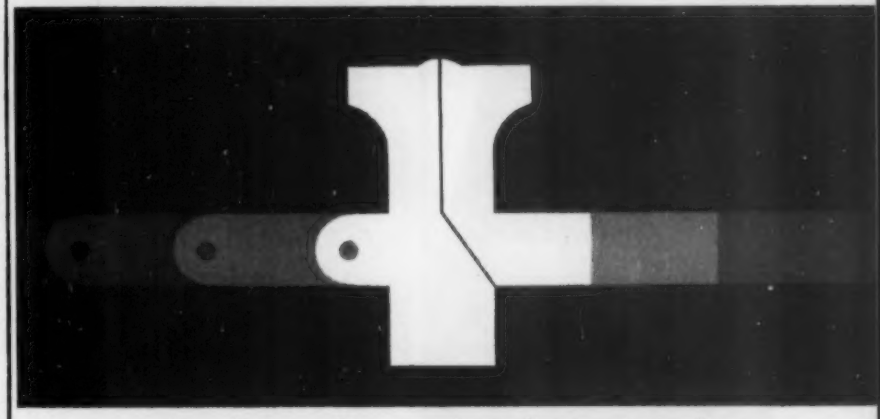
(H-113) Diesel Power Units—Brochure, 22 pp. Describes line of water and air cooled diesels with their maritime and electric power plant applications. Specifications, installation dimensions and construction features. American Marc, Inc, 1601 W Florence Ave, Inglewood, Calif.

(H-114) Automatic-reduced Voltage Starting—Bulletin, 15 pp. Contains selection criteria, typical starting methods, schematics, line current chart, ratings and features of starting equipment for an electric power-driven installation operated by a squirrel cage motor. Allen-Bradley Co, Milwaukee, Wis.

(H-115) Flush Pushbuttons—Catalog, 12 pp. Describes construction details, dimensions, drilling plans, accessories and prices of standard and custom-built stations Westinghouse Electric Corp, Standard Control Div, Beaver, Pa.



Reid Infinite Positioning Controls



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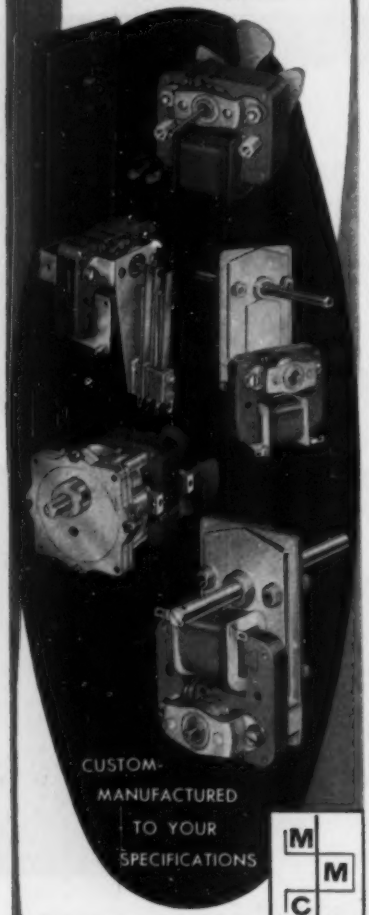

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(H-116) Fans and Blowers—Catalog, 60 pp. Covers line of commercial fans, blowers and related equipment for electronic cooling applications. Contains application material, electrical data, material specifications and some pricing data. Rotron Mfg Co, Schoonmaker Lane, Woodstock, NY.

(H-117) Lighting Controls—Bulletin, 20 pp. Application, wiring and installation data as well as complete specifications given for line of lighting controls for home, industry and commercial use. The Superior Electric Co, 83 Laurel St, Bristol, Conn.

(H-118) Liquid Level Controls—Catalog, 32 pp. Describes specifications, construction, typical applications and indicates required ordering information for the floatless, electrode type. Charles F Warrick Co, 1964 W Eleven Mile Rd, Berkley, Mich.

(H-119) Small Cooling Blowers—Bulletin, 6 pp. Range in capacity from 4 to 150 cfm. Graphs dimensional drawings and specifications. Ripley Co, Inc, 1 Factory St, Middletown, Conn.

(H-120) Gyro Instrumentation—Catalog, 30 pp. Inertial guidance test equipment for ground and air navigation. Includes engineering and material specifications. Sterling Precision Corp. Instrument Div. 17 Matinecock Ave., Port Washington, NY.

(H-121) Motor Compressor Units—Catalog, 4 pp. Specifications, capacities and dimensions of hermetic motor compressors. Includes applications and photographs. Bendix-Westinghouse Automotive Air Brake Co, 950 E Virginia St, Evansville, Ind.

(H-122) Automation Controls—Catalog. 44 pp. Describes construction, applications, specifications and ordering information for counting instruments, switches, magnetic valves, temperature controls, and others. General Controls Co, 801 Allen Ave, Glendale, Calif.

(H-123) Pump and Traction Motors—Brochure, 6 pp. Gives sizes, performance characteristics and construction features. Contains graphs, diagrams and specification form. The Electric Auto-Lite Co, Champlain & Mulberry Sts, Toledo 1, Ohio.

(H-124) Floatless Liquid Level Controls—Catalog, 16 pp. Describes operation, and types of liquid level relays with electrode equipment, automatic alternators, signal and alarm panels, wiring and application diagrams. B/W Controller Corp, 2200 E Maple Rd, Birmingham, Mich.

(H-125) Aircraft Instrument System—Brochure, 22 pp. Explains features, functions and components of integrated flight equipment and its relation to automatic flight control. Lear, Inc, 3171 S Bundy Dr, Santa Monica, Calif.

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SECTION I

ELECTRICAL AND ELECTRONIC COMPONENTS

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DESIGN ABSTRACTS

ELECTRIC CABLES NEED MANY DESIGN SKILLS

In the past 26 years many developments have appeared in insulated electric power cables of all voltages and in all matters relating to them. The importance of the entire field has greatly expanded mainly as a result of (1) the rapid growth in the use of electric power, (2) the increasing use of underground instead of overhead lines, and (3) the sharp rise in costs of cable installations. Some major advances and changes are as follows:

1. Development of many new synthetics to replace natural rubber or as new compounds in the manufacture of (a) insulation for lower-voltage wires and cables or (b) protective jackets.
2. Expansion in types and uses of metallic coverings for lower-voltage cables, and development of lead alloys and aluminum for sheaths for cables for all voltages.
3. Introduction of segmental construction to reduce skin effect for very large conductors.
4. Many new designs of impregnated-paper-insulated high-voltage cables. (Use of pipe-type has grown particularly in the United States.)
5. New designs of points and terminations for all voltages, and development of new insulating materials for this application.
6. Advances in design of conduits, manholes, pipes, trays and supports in air, etc., to increase cable life and reduce costs.
7. Increased utilization by use of higher permissible temperatures for normal operation for practically all types of insulation and by introduction of still higher temperatures for emergency operation.

"Insulated Electric Power Cables," Herman Halperin, Commonwealth Edison Co; Electrical Engineering, May '59, 33 W 39th St, New York 18.

*

Solid-state Circuitry

Too many control engineers still consider a transistor to be only a high-reliability replacement for a vacuum tube. But the transistor has developed many faces, some of which no vacuum tube can match. And the solid-state art which produced it is now fathering many other devices with important potentials in control applications. Here's a look at the present status of solid-state developments from the particularly broad viewpoint of the control engineer—an interpretation of the recent Solid State Circuits Conference by two Control Engineering editors.

"Solid-State Circuitry Promise Today, Practice Tomorrow," E J Kompass and L H Young, Control Engineering, June '59, 330 West 42nd St, New York 36.

*

High Voltage Transmission

The installation of long extra-high voltage transmission lines has become necessary for supplying large blocks of power to load centers from remote hydro-electric and thermal power stations. The physical constants of these lines assume values that render their electrical operation difficult when the distances exceed 200 miles. On short transmission lines the economic power limit is determined by the cost of power, energy losses and the ability of the system to supply higher reactive losses. But on long transmission lines, the transient stability is the determining factor.

"High Voltage Power Transmission," B K R Prasad, The Electrical Journal, Apr 3, '59, Bouverie House, 154 Fleet St, London EC4, England.

*

Low-frequency Phasemeter

The equipment described in this article was developed particularly for use in the study of the vibration characteristics of aircraft structures. In this application the airframe is excited electromagnetically at several points. The resulting movements at other points are studied for differences in phase and amplitude. The same kind of study is also applied between the pilot's control column and the aircraft control surfaces. The mechanical vibrations are converted into electrical form by strain gauge transducers. These waveforms are basically sinusoidal, but square waves and pulses are equally acceptable inputs to the phasemeter. While the phasemeter is capable of working from 1c/s to 3kc/s, the application to aircraft structures is usually limited to an upper figure of 40c/s. At these very low frequencies oscilloscope displays of phase difference present some difficulties, and it is felt that this phasemeter offers one solution to the problem of phase measurement.

"A Low Frequency Phasemeter," N Hambley, A V Roe & Co, Ltd; Electronic Engineering, Jan '59, 28 Essex St, Strand, London, WC2, England.

*

Adaptive Control Systems

Attempt is made to evolve basic philosophy for adaptive control systems. Two systems are discussed, one stable and one unstable. Results are presented in graphic form. This paper was one of five in a session devoted to the theory and concept of control devices able to learn and improve their performance through experience. The other papers were by J. G. Truxal (IRE paper 1.1), M. Freimar (1.2), Hsieh and C. T. Leondes (1.3), P. H. Ellis (1.5).

"On Adaptive Control Systems," Ludwig Braun Jr, Brooklyn Polytechnical Institute, IRE paper 1.4.

*

Magnetic Materials

Developments of the last six years in the theory, research, design and production of both electrically conductive metallic magnetic materials, and semiconductive ceramic oxides are summarized. The various materials are compared in tables and curves.

A bibliography of 80 papers published in the US, England, Germany, France and Sweden between 1950 and 1957 is included. (Note: another article, published this year (1959) in

the same magazine brings the data on this subject even further up to date.)

"Progress Achieved with Magnetic Materials and Their Applications," Franz Pawlek and Karl Reichel; AEG Progress, No. 4—1957; Allgemeine Elektricitatsgesellschaft, Hohenzollerndam 150, Berlin, Grunewald, Germany.

*

Measuring Self-inductances

The paper describes a method of determining the self-inductance of a circuit by direct measurements made at the circuit terminals. The method appears to be particularly useful where the circuit currents are larger than 10 amp, and the application of the method to the determination of the magnetic constants of a synchronous machine is presented.

"A Method of Measuring Self-Inductances Applicable to Large Electrical Machines," Prof J C Prescott and A K El-Kharashi, King's College, University of Durham; Institution of Electrical Engineers, Apr '59, Savoy Place, London WC2, England.

*

Electromagnetic Pumps

The practical design of electromagnetic pumps is discussed with particular reference to construction of the duct/electrode element. Common features of electrical design are explained in terms of a simple theory of tube efficiency.

The scope of the dc pumps in meeting different duties and practical conditions is indicated. Some results of an experimental investigation of dc pump performance in a 4 in-diameter pipe loop are given. The significance of end current loss is indicated, and also the equivalent reduction effected by the presence of a graded fringing field in the end regions. A technique of electrode "wetting" suitable for mercury and stainless steel is described, together with gas entrainment experiments.

Current source

A homopolar generator with mercury collector rings is described. This type of machine would provide an efficient source of current for the dc pump. The newer types of rectifier are briefly compared with the generator for this application.

Reference is made to polyphase traveling-field pumps, and their appropriate application is discussed. Simple theory of design is given, with relationships for optimum design at standard supply frequency.

Other possible designs of large electromagnetic pump are briefly examined and compared with the basic forms of conduction and induction pump.

The various classes of pump suitable for laboratory use are mentioned and general principles of selection are offered.

"The Design of Electromagnetic Pumps for Liquid Metals," D A Watt, Atomic Energy Research Establishment; Proceedings of the Institution of Electrical Engineers, Apr '59, Savoy Place, London WC2, England.

*

Predicting Relay Performance and Reliability

A method of balancing forces by electrical means has been applied to the testing of relays, with direct readout on a conventional X-Y plotter. This system permits prediction of force developed in the moving armature, as a function of ampere-turns applied to relay coil. Force-function curves can be developed that make it possible to determine realistic magnetic and spring tension tolerances.

"Accurate Prediction of Relay Performance and Reliability with Force-function Measurements," T R Welch, Telecomputing Corp. Presented at 6th National Conference on Electromagnetic Relays. Copies available from T C Components, 9151 Exposition Drive, Los Angeles 34.

*

Level-control by Electrical Capacity Measuring

Level-control system developed for petroleum refinery uses a transmitter near point of measurement and recording equipment in convenient location. Has been used for hot and cold liquids, granular materials, corrosive fluids, as well as for certain types of stream analysis.

"Versatile Capacity Measuring System for Level Control and Stream Analysis," Shawhan, Bachofer, Lerner and Wright, Sun Oil Co. Midyear Meeting, May 27-29, American Petroleum Institute, 50 W 50th St, New York 20.

*

Amplifiers with Dynistors or Trinistors

The development of solid state two and three terminal switching devices has made possible the design of physically small linear power amplifiers which have a large power handling capability. Two and three terminal switching devices are referred to as Dynistors and Trinistors throughout most of the paper. Germanium Dynistors and Trinistors make excellent output devices for the linear power amplifier because: (1) the "off" state impedances are aproximately 50,000 ohms; (2) the "on" state impedances are approximately .05 ohms; (3) the Dynistors and Trinistors can be operated at much higher current densities than transistors; (4) the Dynistors and Trinistors need only a pulse to turn "on". Once the Dynistor or Trinistor is "on", the device can be turned "off" by reducing the current through it to a very small value. The characteristics of the germanium Dynistor and Trinistor are summarized in an appendix.

The linear power amplifiers described in this paper use Dynistors and Trinistors as switches in series with the load or output. A magnetic amplifier is used as a transducer to translate input signal magnitude changes into electrical phase angle changes. The voltage produced by the transducer at the electrical phase angle is impressed across a pulse network. This passes the Dynistor or Trinistor turn "on" pulse of current. The Dynistors or Trinistors turn "off" just before the current through the load becomes zero each half cycle of the alternating current.

"Linear Power Amplifiers Using Dynistors or Trinistors," Frank J. Hierholzer, Jr, Westinghouse Electric Corp; AIEE Paper No. 58-1206, 33 W 39 St, New York 18.

From: Electronic Engineering

Liquid Cooling of Electronic Equipment

Intelligent use of heat control in electronic assemblies can produce temperature reductions by natural means. These techniques along with liquid cooling permit safe operation of pressurized equipment which normally fail because of high internal temperatures.

E. N. SHAW
Royal Radar Establishment
Malvern, England

Miniaturization of electronic equipment presents thermal hazards to safe operation. Packing hotter components into smaller enclosures can raise internal temperatures to intolerable levels, resulting in loss of stability, reductions in life-expectancy, and possible early failure of the more temperature-sensitive components. Liquid cooling and component segregation is one answer to the problem.

Customary approach has the total heat dissipation of the equipment determining the skin temperature of the container, which acts as a barrier between hot interior and cold exterior. Internal temperature is reduced by external cooling, but only to the same extent as the reduction in container temperature. A high temperature gradient remains in the interior and acts as the motive force required for the transfer of the entire dissipation through the container barrier.

Liquid cooling has the initial advantage of being adaptable to sequential cooling within a container, and augments any spatial segregation of components. It is applied first to temperature-sensitive components to counteract any heat transfer from hotter areas; progresses to intimate contact with the heat source, where the coolant absorbs heat and withdraws it bodily. Heat is not forced through the container surfaces, and the container can be lagged to prevent heat intake in unfavorable environments.

EXPERIMENTAL ASSEMBLY

Mechanical features, Fig. 1, emphasize segregation of equipment in cold, warm and hot zones. Total of 250 W is crammed into the available space although experience indicates that without liquid cooling the high thermal loading would melt the assembly in a matter of minutes.

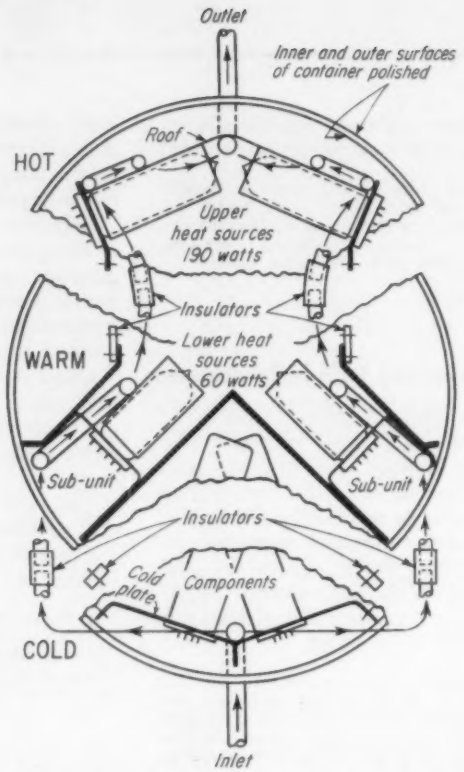

Fig. 1—Exploded view of 7 in. dia, 10¼ in. long container. Surface area is 308 sq in.; volume 808 cu in. Temperature-sensitive components take up one-quarter of the total volume; remaining 606 cu in. holds heat source, consisting of 12 tubes in the warm zone and 10 tubes in the hot zone, all operated as cathode followers at their maximum rated dissipation. Heavy lines indicate structural members separating heat zones.

Power supply is flexible: anode dissipation may be reduced to zero, leaving only 70 W heater dissipation which is reduced by lowering heater voltage.

Liquid cooling system enters the assembly through a large diameter common inlet at the lowest point in the front panel. Here it splits, and the ¼ in. copper pipe bent in a hairpin shape has the lower limb in good thermal contact with the chasis and both structural members. Upper limb is soldered to the rear of the sub-unit supporting plates. Heat transfer between source and chasis is prevented by the coolant flow from lower to upper limb, absorbing heat from surfaces in intimate contact with the sub-units and conveying it to the larger upper assembly.

Upper assembly holds the 10 power pentodes in split brass tubes soldered to the underside of the roof-shaped upper section, which is supported by, but insulated from, the upper structural members. A hairpin of copper tube is soldered to each side of the outer roof surface, with the upper limbs joining the larger diameter tube running under the roof crest to form a common outlet.

Twenty double-ended (differential) thermo-couples measure the temperature rise above room ambient (20 C). Values are recorded in a vertical plane through the center

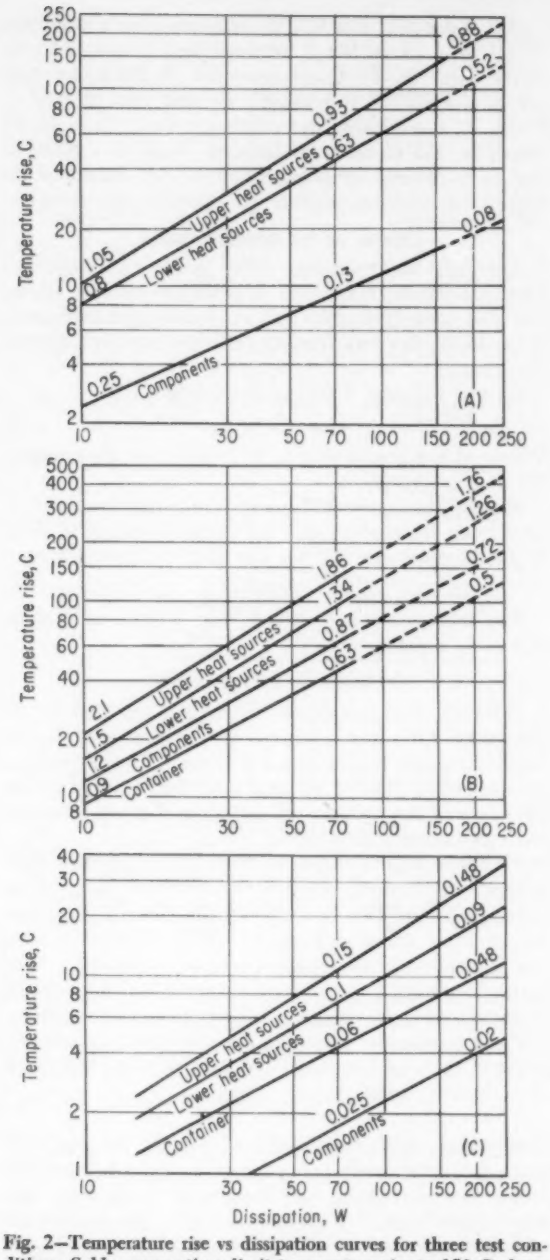

Fig. 2—Temperature rise vs dissipation curves for three test conditions. Solder connections limit temperature rise to 150 C above ambient, but log-log scale permits straight line extrapolation of temperatures to full 250 W dissipation as shown by the dotted lines. Values on curves indicate thermal resistance to ambient in Centigrades/Watt.

(hottest) section of the final assembly. Three test conditions are shown in Fig. 2; (A) in free air, (B) in a polished container, and (C) in the container with water flowing through the cooling tubes.

EXPERIMENTAL RESULTS

With solder melting at 180 C, temperature is not permitted to rise above 170 C (150 C rise above 20 C ambient). In free air, assembly is safe up to 160 W loading, with the certainty of failure at slightly greater dissipation. Disintegration would occur at 80 W with the assembly in an airtight container as a result of changing from direct convection cooling to indirect cooling of the container surfaces.

At the full 250 W dissipation, Fig. 2 (A), the upper heat sources would have reached their maximum temperature rating of 250 C; lower heat sources would have attained a temperature of about 150 C which is marginal for some units. Component rise is only 20 C. In an airtight container, Fig. 2 (B), full-load conditions would be intolerable with temperatures of 460 C, 300 C and 200 C respectively.

In contrast, by using a liquid coolant flowing at 25 lb/hr, the temperatures are well within what is considered safe. In fact, the temperature rise in the component area is only 5 C, making it a very desirable area for locating temperature-sensitive items such as transistors. The safety factor is also excellent; 1060 W dissipation to make the water boil at the outlet, and 7.1 KW to boil the assembly dry.

THERMAL RESISTANCE

The effectiveness of liquid cooling is governed by thermal resistance, R_t, expressed in C/W. It is defined as the temperature difference between two points on an assembly, or between any one point and ambient, divided by the total thermal loading responsible for the difference.

Thus, in Fig. 2 (A) the 65 C rise of the upper heat source at a loading of 70 W, gives a thermal resistance, R_t, equal to 0.93 C/W. Values of R_t are given along the curve and vary from 1.05 at 10 W to 0.88 at 250 W. The 9 C rise in component temperature at 70 W gives a low of 0.13 C/W thermal resistance between components and upper heat source.

With the assembly in a container, Fig. 2 (B), values of R_t for the upper heat source are doubled (melting point is reached at half the previous loading) varying from 2.1 to 1.76 C/W, while R_t between container and ambient ranges from 0.9 at 10 W to 0.5 at 250 W.

If the R_t between container and ambient is the external thermal resistance, R_t ext, and it is subtracted from the R_t between the upper heat source and ambient at common loads, the internal thermal resistance, R_t int, is obtained and ranges from 1.2 to 1.26 C/W. If this small variation over a 25:1 change in load is disregarded, the total thermal resistance between a point in the interior and the ambient is the sum of a constant internal resistance and a variable external resistance. For a thermal load W, a point in the interior will attain a temperature rise

$$\Delta t = W(R_t\,int + R_t\,ext) \qquad (1)$$

The significance of this expression is apparent when it is realized that some reduction in internal temperature rise is imperative if the equipment is to survive. Should the required reduction be less than the temperature rise of the container, (W)(R_t ext), a conventional cooling method is possible, such as increasing the container emissivity and resorting to forced convection cooling of the container.

If the required temperature reduction is greater than possible by letting R_t ext approach zero, there are three

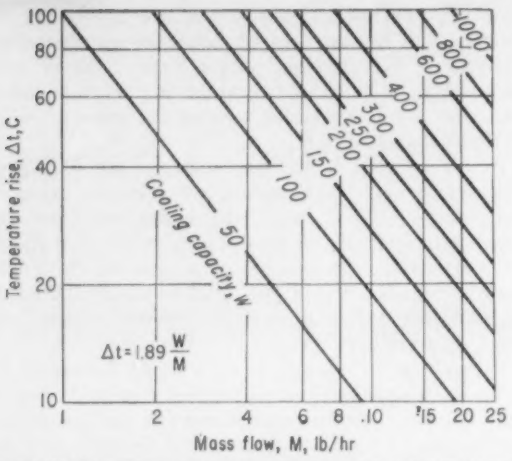

Fig. 3—Cooling capacity of water. Other coolant relationships are obtainable by considering the specific heat of the new coolant. For example, a coolant of specific heat 0.5 would have half the indicated cooling capacity, or an indicated cooling capacity would need twice the product of Δt and M.

possibilities: derate the assembly by removing heat-dissipating elements until tolerable thermal loading is attained; reduce R_t *int*, which is greater than R_t *ext* and much less tractable; or use liquid cooling. Examples of these methods are given.

INDIRECT COOLING BY NATURAL CONVECTION

Assuming that the container is in truly still air at such low dissipation that heat transfer can occur by conduction only, then the high thermal resistance is caused by the low conductivity of the air. Greater dissipation will increase surface temperature, heating the air and decreasing its density. It will eventually be replaced by colder and more dense air. Transfer of heat from the container surfaces progressively reduces R_t ext. However, this method is not very effective.

As indicated in Fig. 2 (B), the assembly could melt at loads in excess of 80 W, although continuous operation at 70 W is safe. But the R_t ext is only 0.63 C/W based on a temperature rise of 130 C for the upper heat source and 44 C for the container.

With an assembly capable of dissipating 250 W having to be derated to 32% of this maximum to survive, or 28% for continuous operation, forced convection must be attempted to reduce container temperature.

INDIRECT COOLING BY FORCED CONVECTION

If air is forced across the container surfaces to drop the 44 C temperature rise to zero, the upper heat source would rise by the product of 70 W and a constant R_t int of 1.23 C/W or 86 C, or just 44 C less than 130 C recorded with natural convection. The internal temperature drop would thus be the same as that produced externally.

However, the container is cooled to an ambient of 20 C, maximum power that could be dissipated would still be restricted to 150 C rise considered safe. Melting point would be reached at 150/1.23 = 122 W, or 49% of the maximum dissipation.

At full dissipation of 250 W there would be a difference of 250 × 1.23 = 308 C between heat source and container skin. If the temperature rise of the upper heat source is restricted to a completely safe value of 130 C above 20 C ambient, the container would have to be cooled to 178 C below ambient or −158 C. A 20 C rise in container temperature caused by decreased air flow or rise in air temperature would destroy the assembly.

WATER AS THE COOLING LIQUID

Although not necessarily ideal under all conditions, water has certain advantages. It is readily available, stable, non-toxic, non-flammable, and has a suitable combination of physical properties—viscosity, density and high specific heat (unity).

Cooling capacity, (W), of water is given by

$$W = 0.527M(\Delta t) \qquad (2)$$

Where M is the mass flow in lb/hr and Δt is the temperature rise in centigrades.

Because thermal conditions in the assembly must depend upon the cooling inlet and outlet temperature, Δt is of prime importance and the equation can be rewritten

$$\Delta t = 1.89(W/M) \qquad (3)$$

This relationship is plotted in Fig. 3 for a wide range of cooling capacities.

CONTROL OF HEAT TRANSFER

Indirectly cooled systems require all the heat to be transferred from the assembly to the container before being dissipated from external surfaces. Integral cooling systems extract most of the heat from the assembly by the mass flow of the coolant; the container dissipating only a small amount of residual heat.

Presented with a choice of heat transfer paths—from assembly to coolant, or to container—the object is to manipulate heat flow by reducing the thermal resistance between heat source and coolant and increasing the thermal resistance between heat source and container. For optimum results it is necessary to control all three forms of heat transfer, by conduction, convection and radiation.

The experimental assembly, Fig. 1, is an excellent example of the ways to achieve 95% efficiency at a mass flow of 25 lb/hr of water.

Conduction. Both inlet and outlet pipes are insulated from the front panel to prevent a high conductivity surface from interfering with the coolant temperature rise, which determines its thermal content. The conductive path formed by copper tubing in the interior is broken for the same reason, and to improve thermal segregation between hot tubes and temperature-sensitive components.

Because the structural members, front panel and container, are all in good thermal contact the cold plate and hot upper assembly are both insulated from the structural members, to which only the sub-unit chassis are attached. With the conductive path to the container broken, steps are taken to encourage heat flow into the coolant by intimate contact between the split brass tubes holding the tubes and the copper tubes containing the coolant.

Convection. Hot air from all sources rises to the upper surface of the container, to which it gives up its heat as

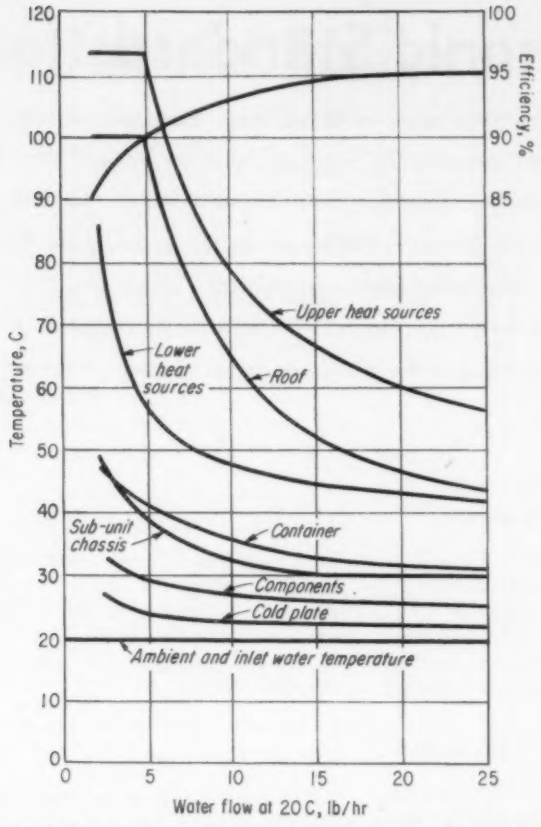

Fig. 4—Temperature vs mass flow for assembly at maximum loading of 250 W. Latent heat of vaporization being 284 W-hr/lb for water, the assembly would boil dry below a flow of 1 lb/hr, causing a complete failure.

it divides into symmetrical streams down the container sides. Contact with the container upper surface is prevented by the roof-like shape of the upper assembly. The roof-like shape conveys the intercepted heat into the cooling tubes attached to the assembly roof.

Radiation. Transfer is minimized by reducing both the absorptivity of the container interior and the emissivity of the assembly surfaces. Ten vitreous resistors used as cathode loads for the ten upper tubes are located inside the roof to prevent radiation (and convection) transfer to the container. Heating of the component area by radiation from the lower tubes is prevented by screening action of the inverted V lower structural member.

By these methods an initial extraction efficiency of 75% is increased to 95% in the final experimental assembly. In general, the objective is intimate contact between coolant and heat source, with escaping heat intercepted by a surface, preferably cooled, to prevent it from reaching the container.

With the coolant inlet temperature the same as ambient, as occurred here, it is impossible to withdraw all heat in the container because to absorb power the coolant temperature must rise—18.9 C at maximum flow—with the mean temperature rise of the assembly giving the motive force for some heat transfer across the internal thermal resistance. A condition of balance, without heat transfer to the container, could be established with a coolant temperature below ambient and a mass flow rate such that Δt just brought the mean internal temperature up to ambient, allowing the container to remain truly neutral.

EFFECT OF VARYING MASS FLOW

Changes in extraction efficiency and internal temperatures with varying rates of mass flow are shown in Fig. 4. As mass flow decreases, the coolant temperature rise increases in accordance with Eq (3) and the higher mean temperature of the assembly permits a larger proportion of the 250 W to escape across the constant R_t int to the container, with a consequent drop in extraction efficiency.

Insulating the coolant inlet pipe from the front plate, Fig. 4, is justified by the small change in cold plate and component temperatures. These are lower than those of the container and sub-unit chassis, representative of the structural temperature. Insulation and effective thermal segregation made the component temperatures almost entirely dependent on coolant inlet temperature, being only slightly affected by changes in mass flow rate.

Heat source temperatures will rise and fall linearly with coolant inlet temperature; they react to changing flow according to Eq (3), rising steeply with decreasing flow until the coolant boils at the hottest portion.

Latent heat of the coolant does not increase extraction efficiency, as in an evaporative cooling system. Only effect is to establish a maximum temperature rise in the region where boiling occurs. Further reductions in flow increases the area and the mean temperature of the assembly, causing extraction efficiency to diminish.

PRACTICAL APPLICATIONS

The internal temperatures of an assembly depend upon the coolant inlet temperature and the rate of mass flow. If a thermally neutral container is used to protect the interior from environmental changes, constant conditions can be established by controlling these quantities.

Mobile equipment can carry only limited supply of coolant, thus restricting its operational time. For example, a tank containing 25 lb of water at 20 C would maintain the terminal conditions in Fig. 4 for one hour if allowed to run to waste. Halving the rate of flow would let conditions for 12.5 lb/hr be maintained for two hours.

In a closed circuit system, a 2.5 gallon storage tank, using a bottom inlet and top outlet, with a large vertical area could maintain the Fig. 4 terminal conditions for one hour. After an hour, the constant inlet temperature would rise by 17.9 C (18.9×0.95). By using a mixture of about 5 lb of water with added anti-freeze and 20 lb of ice, the latent heat of fusion of ice would increase the coolant storage capacity, and maintain inlet temperature at nearly 0°C, improving extraction efficiency.

REFERENCE:
Liquid Cooling of Electronic Equipment by E. N. Shaw, Royal Radar Establishment, Malvern, England. Published in Electronic Engineering (British), September, 1958, pp 516-523.

Electronic Standards for

From: Control Engineering

The following standards have been extracted from "Electronic Standards for Industrial Equipment" prepared by a task group of the General Motors Plant Engineering Electronics Committee to insure safe and dependable operation of electronic equipment in GM's manufacturing processes. The standards listed here are selected from a considerably larger original list so that the numbers do not correspond with those in the complete standard. The exact wording of the standards listed has been retained.

GENERAL MOTORS
ELECTRONICS COMMITTEE

GENERAL SPECIFICATIONS

1. The purpose of these Electronic Standards is to provide detailed specifications for the construction and application of electronic apparatus to industrial equipment which it is believed will promote:

a. Safety to personnel
b. Uninterrupted production
c. Long life of the equipment
d. Ease and low cost of maintenance

2. Wherever electronic and electrical equipment are employed together, these Standards shall apply only to the electronic equipment, and not to the electronic equipment or any related equipment, and shall be supplemental to the JIC Electrical Standards for Industrial Equipment.

STANDARDS ON CONSTRUCTIVE PRACTICE

General

1. The use of subchassis construction is recommended.
2. Subchassis which have the same function and rating and are electrically identical shall be interchangeable.
3. Test points shall be brought out for checking essential wave forms and voltages where terminals are not otherwise provided.
4. Test points for measuring voltages in excess of 1,000 volts shall be provided with voltage dividers.
5. Drawers or other plug-in chassis shall be guided and locked.
6. All hardware shall be plated or of a noncorrodible material.
7. Lock-washers or other locking devices shall be used.
8. Resilient washers shall be used whenever plastic, phenolic, porcelain or other brittle materials are bolted in assembly.
9. Control knobs shall be fastened by two set screws or other equivalent means.

Soldering and electrical connections

1. A solder with a noncorrosive flux, such as rosin, shall be used.
2. All parts shall be "tinned" before soldering unless the part is specifically plated to insure a good soldered joint (e.g., "AN" type connectors having gold-plated contacts).
3. All parts shall be cleaned prior to soldering.
4. A minimum amount of solder shall be used on all connections except tubular or cup-type terminals. For tubular or cup-type terminals, the cavity shall be filled with solder.
5. Insulation shall not be damaged by soldering.
6. Components which may be damaged by heat when soldering shall be suitably shielded.
7. Compression-type lugs and connections may be used. All other connections shall be soldered.

Interconnection cables and connectors

1. The external covering on the cable shall be oil-resistant, such as neoprene, polyvinyl chloride, or equivalent.
2. When connection from the shield to both connector pin and the cable clamp is indicated, the shield shall be connected directly to the pin and the pin connected to the cable clamp by hook-up wire. Connection to the clamp shall be by a lug.
3. The cable clamp of the connector shall be clamped on the outer insulated covering of the cable. The cable shall be built up if necessary, to insure good clamping.
4. When more than one plug and receptacle are used and where interchange of plugs may result in injury to personnel or damage to equipment, they should not be interchangeable.
5. The energized portion of the circuit shall be connected to the female end of plugs and receptacles.

Wiring

1. General-purpose hook-up wire shall consist of stranded tinned copper not less than AWG 22, with thermoplastic insulation.
2. Shielded cable, single or multiple conductor, shall consist of stranded tinned copper not less than AWG 25 size for single conductor wire used in subassemblies and not less than AWG 22 for all other uses. The wire or wires shall have thermoplastic insulation, metallic shield, and an oil and moisture resistant covering, such as vinyl plastic.
3. All conductors and multiconductor cable used on industrial equipment

Industrial Equipment

shall have insulation rated at 600 volts, except for the following:
a. The internal wiring on electronic panels shall have insulation adequate for the voltage on that wire. In no case shall insulation less than 300 volts be used.
b. Special wiring of sufficient insulating capacity to protect equipment and personnel shall be used when external wires and cables must carry an excess of 500 volts.
4. Current carrying capacity. The values of current ratings (amperes) of conductors given in Table I are for normal use. These values must be modified for special insulations and locations.
5. All wires and cables shall be secured and protected to prevent strain on the wire termination or fraying of the insulation.
6. The internal wiring of electronic equipment shall conform to the color code listed in Table II, which is based on the EIA code. This conformance shall be indicated on the schematic diagram and on the equipment. Multicolored wires shall be indicated by two or more abbreviated symbols (e.g. Wh.-Rd.). The base color shall be the first color in the series.

Table II—Wiring Color Code

Base color	Abbreviation	Circuit
Black	Blk	Grounds, grounded elements
Brown	Brn	Heaters or filaments, off ground
Red	Rd	Power supply high B plus
White-Red	Wh-Rd	Power supply low B plus
Orange	Or	Screen grids
Yellow	Yel	Cathodes
Green	Gn	Control grids
Blue	Blu	Plates
Violet	Vil	Miscellaneous
Grey	Gy	AC power line
White	Wh	Power supply B minus

Table III—Current Capacity of Printed Wires

Line width, in.	Amperes	Ohms/in.
1/4	3	0.0009
1/8	1.5	0.0018
1/16	0.75	0.0035
1/32	0.40	0.007

Table IV—Voltage Rating of Printed Wires

Voltages*	Minimum line separation, in.
0–150, incl	1/32 (0.031)
Above 150–300, incl	1/16 (0.062)
Above 300–500, incl	1/8 (0.125)
Over 500	0.0003 in. per volt

* Maximum peak voltage during normal operation.

Printed circuits

1. Plastic boards with copper laminate on one or both sides may be used in place of conventional wires within electronic units.
2. The base material of the plastic board shall be grade XXXP or equivalent.
3. Plastic boards shall not be less than 1/8 in. thick.
4. Copper shall be 100 percent International Annealed Copper Standard (IACS) and no thinner than 2 oz per sq ft (copper 0.0027 in. thick).
5. Bond strength shall be not less than 700 lb/sq-in.
6. Currents for 0.0027 in. thick copper shall not exceed values shown in Table III.
7. Line width shall not be narrower than 1/32 in.
8. Line separation shall be in accordance with Table IV.
9. Sharp corners should be avoided.
10. Lands shall be used wherever parts or external circuits are used.
11. Printed circuit boards should be protected from deposits of conducting

Table I—Current Carrying Capacity of Wires

AWG wire size	Current rating, amperes
22	3
20	5
18	6
16	8
14	12
12	16
10	24

Mounting and clamping

1. Mounting hardware shall be designed to facilitate replacement of parts and assemblies.
2. All miniature tubes shall be held in place by shields or clamps. All other tubes not mounted in an upright position shall be clamped.
3. Transistors shall be mounted in sockets where practicable. When transistors are mounted on heat sink or other special mounting, wires shall be connected to a terminal point to facilitate replacement.
4. Rivets and welds shall not be used to mount components.

STANDARDS ON GROUNDING

1. All exposed metal parts shall be at ground potential.
2. Where the equipment is portable and the power connection is by means of a plug and flexible cable, the plug shall be provided with a grounding pole. The grounding pole shall make connection before any current carrying poles are made. The grounding pole connection shall not be broken.
3. A copper or other corrosion-resistant conductor shall be used for grounding purposes.
4. The size of the ground conductor shall be equal to the power conductors.

REFERENCE:
Industrial Standards for Industrial Equipment by General Motors Electronics Committee. Published in Control Engineering, November, 1958, p 101.

Design and Construction of Transistors

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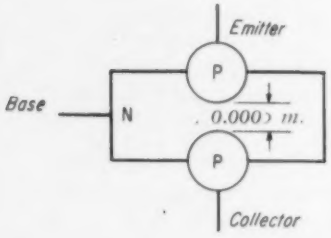
From: RCA Booklet

Alloy-Junction Transistor—Base of the transistor is a wafer of N-type semi-conductor. Collector and emitter regions are formed by placing pellets of a trivalent impurity on opposite sides of the N-type wafer and applying heat so that the impurity alloys into the wafer. This alloying process forms regions of semi-conductor material of the P-type which constitute the emitter and collector.

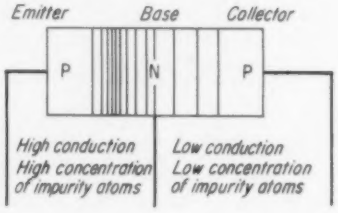
Complete control of this process



gives separation between the emitter and collector of about 0.0005 in. which permits a short electron transit time from emitter to collector. In addition, the resistance between the base connection and either the emitter or collector is low because of the relatively thick N-type wafer used. Finally, the various capactive effects of the emitter and collector are kept to a minimum because of the very small areas of P-type regions.

Transistors made by this process exhibit 12 db of gain at 10 millicycles and a frequency cut-off of about 75 millicycles. Construction method is feasible for both PNP and NPN types of transistors.

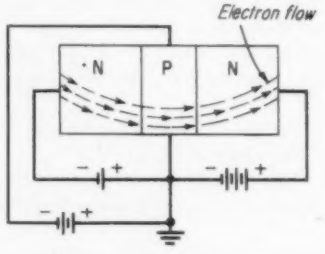
Drift Transistor—Method used to reduce the transit time for a given base dimension is to establish a field within the base region that will directly aid the passage of holes or electrons. Field



is established by varying the conductivity of the base region so that conductivity is high near the emitter and low near the collector. Base material conductivity is controlled by the distribution of impurity atoms during manufacture. In such a non-uniform conductivity distribution, the electrons tend to drift out of the high concentration region. Result: an electrical field is set up caused by the positive charge on the atoms from which the electrons left.

Positive charge of the drift field tends to keep the remaining electrons near the emitter side. Holes injected by the emitter are accelerated by the drift field toward the collector because of their opposite charge. Drift field reduces the transit time by ¼ of that of an alloy-junction transistor of the same base dimension. Also, high frequency performance is improved because the high conductivity of the base region near the emitter reduces input resistance. Low conductivity near the collector region results in a low collector capacitance. Thus, the upper frequency limit is higher than that of a PNP unit; oscillate at frequencies up to 300 mc.

Tetrode Transistor—Additional lead is attached to the base region on the side opposite to that of the original base connection. The bias voltages to operate are similar to those required by a NPN type of transistor. Emitter is biased in the direction of greatest electron flow, and the collector is biased in the direction of least flow. Fourth lead is biased at a negative potential which is greater than the normal emitter to base potential.

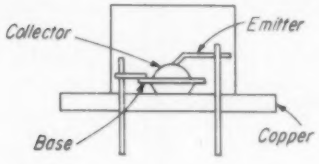


This negative potential restricts the electrons flowing through the base region so they flow through a relatively narrow area of the base region.

Advantage is an improvement in high frequency operation. Improvement is obtained from the reduction of emitter and collector capacitance caused by the reduced effective area of each region adjacent to the base region, as well as a reduction in base

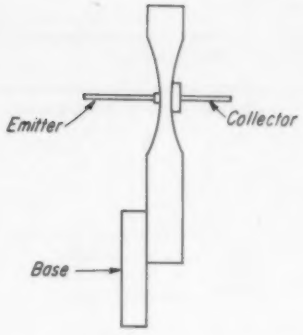
resistance because of the shorter path travelled by the base current. A limitation is its power handling capabilities. In forcing the electrons to flow in a narrow channel in the base region there is a reduction in the collector current capability. However, the power requirements for the high frequency stages in many commercial applications are very low.

Power Transistors–Along with high current and voltage capabilities, the effective dissipation of heat is one of the prime requirements for a power transistor. In some circuits an increase in transistor temperature will cause a bias point shift resulting in an increase in dissipation and hence increasing the temperature even more. In properly designed circuits this effect can be minimized. However, unless the heat generated can be removed efficiently, the transistor junction temperature will rise to a high level and, in time, degrade the transistor performance.



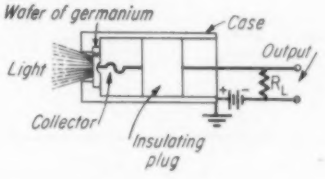
Most of the heat dissipated is generated at the collector junction. To simplify removal of this heat the collector dot is generally fastened directly to the case of the unit. Provision is then made for the case to be directly connected to a chasis or other heat dissipating surface. Power transistors of the structure described are available and are capable of dissipating up to 25 watts in practical application.

Surface Barrier Transistors–Structure is similar to an alloy transistor. Major difference is that instead of alloying dots deeply into the base material to obtain a narrow base width, two wells are electrochemically etched into the base material until they are separated by only a few tenths of a mil. Indium is then plated on both sides and emitter and collector contacts made. Units have a frequency cut-off of about 40 mc.



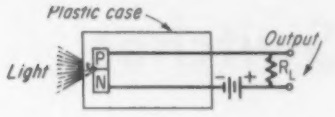
Recently, the micro-etching techniques have been applied to drift transistor structures. The units are known as micro-alloy diffused transistors and have a frequency cut-off greater than 250 mc.

Photosensitive Transistors–There are three groups according to construction: (1) point contact; (2) PN junction; and (3) photo transistor. Mechanical features are similar to the conventional transistor.



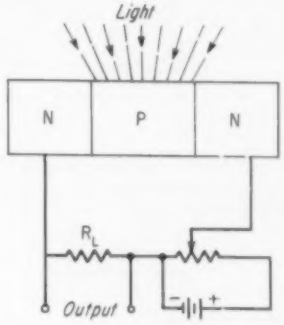
Point contact use a wafer of germanium. One side has a spherical dimple which reduces the thickness at the center to about 0.003 in. Wafer is force-fitted into one end of a metal cartridge and a pointed phosphor-bronze wire is brought into contact with the wafer at its center. Wire is the collector. The other end of the wire fastens to a metal pin contact embedded in an insulating plug positioned at the opposite end of the case. Second electrical contact is the case.

Wafer is made of N-type semi-conductor and is biased in the direction of least current flow. When light is directed on the germanium wafer a number of covalent bonds are broken, thus producing an equal number of holes and electrons. Under the influence of the applied electric field, the electrons travel to the positive terminal of the battery and the holes to the negative terminal. It is because of the additional carriers of current made available by the action of light on the



N-type germanium, that there is an increase in current flow through the circuit.

To insure that maximum current response is obtained when the light rays fall in the vicinity of the point contact a small glass lens is used to focus the



light rays into a narrow beam which is restricted to the desired area of the N-type wafer.

PN junction assembly may also be devised with comparable results. The response will be greatest when light is directed at the junction.

Phototransistor uses an NPN-type of construction. Only the central base section is made photosensitive. Bias battery is adjusted so that very little current flows through the transistor. However, when light is focused on the base section, holes are formed in sufficient quantity to produce an increase in current to operate a relay directly.

REFERENCE:

Transistor Fundamentals and Applications by W. W. Lenz and W. W. Cook, RCA Service Company, Camden, N. J. Published by Radio Corporation of America, 1958, 43 pages.

From: Electronics

Solid-state Switches

Tabulation of important characteristics of commercially available *pnpn* and *pnpm* semiconductor switching diodes.

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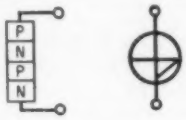
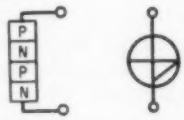
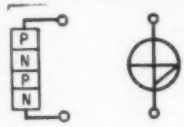
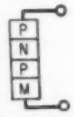
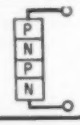
TABLE 1–Trade Names, Symbols, Characteristics and Commercially

Trade Name	Manufacturer	Type Number and Material	Structure Manufacturer's Symbol
Dynistor	Westinghouse	WX806 (Ge)	
Four-Layer Diode	Shockley Transistor Corp.	4N20D to 4N200D (Si)	
Four-Layer Diode	Shockley Transistor Corp.	4N20AD to 4N200AD (Si)	
Four-Layer Diode	General Transistor	(Ge)	
Switching Diode	ITT Labs	CP-622 (Ge)	
Switching Diode	ITT Labs	CP-624 (Si)	

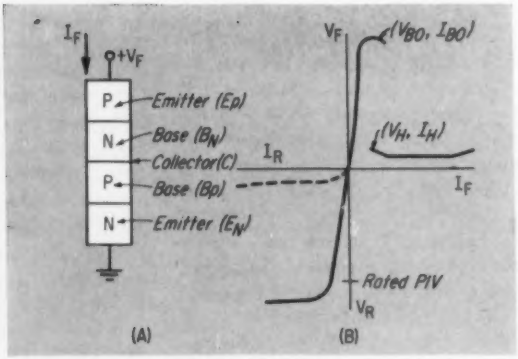


Fig. 1–Schematic diagram and terminology for (A) a pnpn diode and (B) characteristic curve of pnpn diode with zero base current.

A number of solid-state switching diodes have been introduced commercially over the past two years. All of the presently available diodes of this type are listed in Table I. Specifications are for illustrations only.

All diodes listed are *pnpn* or *pnpm* devices with two terminals. Fig. 1 (A) shows construction of the diodes and terminology used to designate various regions and junctions. In accordance with proposed AIEE standards, the various junctions and regions are labeled according to their function and a subscript is used to denote the type of semiconductor material. This method avoids any ambiguity in identifying the regions of a *pnpn* device.

Available Solid-state Switching Diodes

AIEE Symbol	IRE Symbol	Range of V_{BO} I_{BO}	Forward Voltage Drop at Rated Current	Turn On Time, Recovery Time	Reverse Characteristic	Essential Characteristics
		25–250 v 1–10 ma	0.5–1.0 0.5 amp	0.01 sec	Conducts	Low turn-on time
		20–200 v 0–0.2 ma	0.9 v 50 ma	0.1 sec 0.2 sec (50 ma)	Blocks	Low breakdown currents. Close control of breakdown voltage. Pulse currents to 2 amp
		20–200 v 0–0.2 ma	1.0v 300 ma	0.1 sec 0.3 sec (300 ma)	Blocks	Same as above except pulse currents to 20 amp
		40–100 v 0–0.5 ma	0.5 v 500 ma		Blocks	Low breakover current, low turn-on time
		20–100 v 1–10 ma	1.0 v 10 ma	100 sec	Blocks	
		20–100 v 20–200 ma	1.3 v 2 amp	. . . . . . 5 sec	Blocks	High-current operation

A number of manufacturers have introduced their own symbols for their devices which are given also in the table as are the present IRE symbols. Symbol standardization, however, is gaining in prominence.

General voltage-current characteristic of a switching diode is shown in Fig. 1 (B). Forward voltage and current, (V_F, I_F), correspond to the quadrant in which the switching characteristic occur. The reverse voltage and current, ($V_R I_R$), correspond to the opposite quadrant. Maximum forward voltage which the device can maintain is called the breakover voltage, V_{BO}, and the current at this point is called the breakover current, I_{BO}.

A switching diode can be turned on by momentarily exceeding the breakover voltage. The device will then remain in the on condition as long as a forward current flows which is greater than the holding current, I_H. If the forward current falls below I_H for a short time, the device will turn off and revert to the blocking state.

Reverse voltage-current characteristic similar to that of a conventional rectifier as shown by the solid line in Fig. 1 (B). For a device having this type of reverse characteristic, the peak inverse voltage and breakdown voltage are measured and specified in a manner similar to that used with conventional rectifiers.

For some devices the reverse voltage current characteristic exhibits a conducting characteristic as shown by the dotted line in Fig. 1 (B). When these devices are used in applications where they must withstand a reverse voltage, a series rectifier must be used. This use of a series rectifier will increase total forward voltage drop and reduce switching efficiency.

REFERENCE:

Two-terminal Solid-state Switches, by T. P. Sylvan, Application Engineer, Semiconductor Products Dept., General Electric Co., Syracuse, New York. Published in Electronics, February 22, 1959, p 63-64.

From: Lubrication Engineering

Bearing Damage by Electrical Currents

Damage produced by bearing current, type of damage, sources of bearing current, methods of eliminating or reducing such damage.

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H. N. KAUFMAN
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Bearings are not expected to carry current, but there are instances where it occurs. Sometimes, it is by design; more often it is by accident. Under certain conditions, bearing damage is caused.

Although other effects are sometimes present, the principal damage caused by bearing currents is due to sparking between the bearing and the journal surfaces, or between the balls and the races. High voltage is not necessary; damage can occur at potentials well below one volt.

Main consequence is pitting of the surfaces. This results in wear due to the removal of fused metal particles, but the roughening of the surfaces caused by pitting also produces wear by purely mechanical means. A further danger is deterioration of the lubricant and the lubricating system by spark debris. Heating of the part is also dangerous as it may result in bearing or lubricant damage.

SOURCES OF BEARING CURRENT

Electrical currents in bearings may be produced by: potential applied to shaft; dissymmetry effect; shaft magnetization effect; and electrostatic effect.

Potential applied to shaft. The most obvious source of bearing currents is, of course, where a potential is inten-

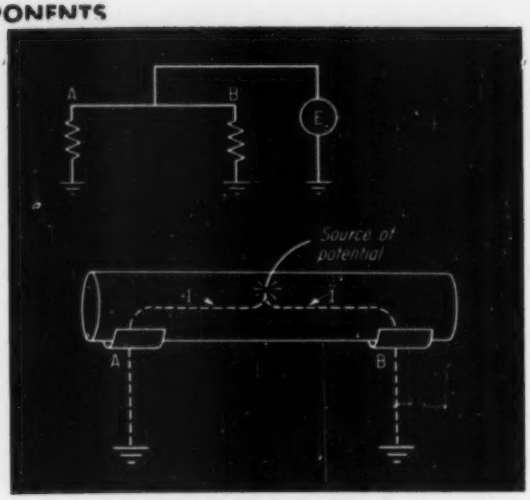

Fig. 1—Potential applied to the shaft. This may be accidental or intentional. Also shown is corresponding electrical circuit.

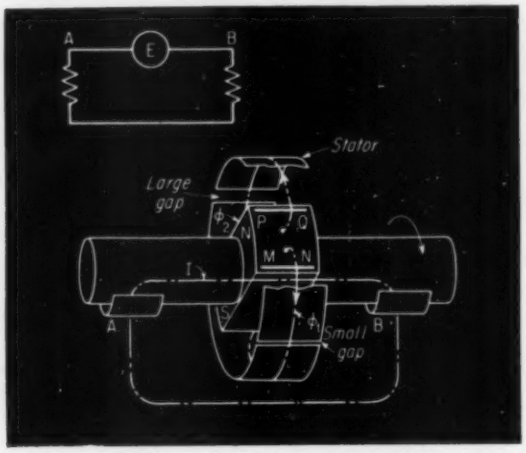

Fig. 2—Dissymmetry effect. Corresponding electrical circuit is shown. Various factors cause this effect such as air gap, flux density and others which cause bearing currents.

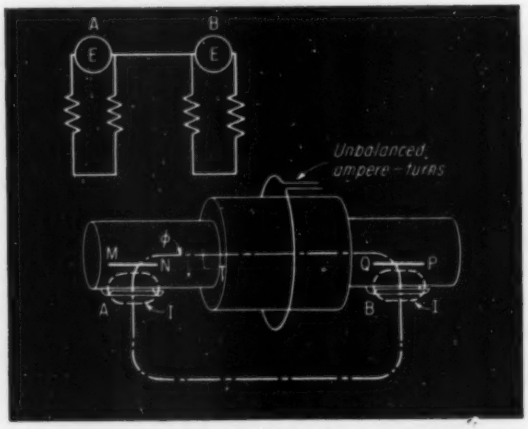

Fig. 3—Shaft magnetization effect with corresponding electrical circuit. Cause is unbalanced ampere-turns which may surround the shaft and cause it to become magnetized.

tionally or accidentally applied to the shaft and current flows through the bearings or other contacting parts to ground. Fig. 1 shows this as well as the corresponding electrical circuit.

Dissymmetry effect. Even though a potential is not directly applied to a shaft, bearing currents may arise through induced effects. While the characteristics (frequency and wave form) of the bearing current which is produced is influenced by the rotor and stator arrangement of the machine, the principle by which the current is generated is shown in Fig. 2. If the machine could be perfectly constructed so that the reluctance of the magnetic circuit was uniform around the periphery of the stator, no bearing currents would be generated. If, however, there are dissymmetries in the magnetic circuit, as occur in all practical machines, bearing currents may occur.

Various sources of dissymmetry may be present, such as differences in the spaces between the ends of laminations and nonsymmetrical distribution of slots. These are represented, Fig. 2, by the dissymmetry produced by differences in the size of gaps between the two semicircular sections of a stator.

Bearing currents originate because each of the two fluxes ϕ_1 and ϕ_2 varies in value during each revolution of the shaft. Since flux ϕ_1, for example, must flow through either the small or large gap, but never both gaps simultaneously, the magnitude of ϕ_1 will rise and fall depending upon the position of the shaft. As ϕ_1 increases and decreases, it cuts any conducting material present, such as the imaginary conductor *MN*, causing an alternating emf to be set up between *M* and *N*. The emf generated by the change in flux ϕ_2 reinforces that generated by ϕ_1. This puts an alternating potential between the extremities of the shaft and tries to set up a current which flows out through one bearing and in through the other.

Shaft magnetization effect. Another source of bearing current sometimes found in electrical machines is the shaft magnetization effect. This is caused by any unbalanced ampere-turns which may surround the shaft. Such turns cause the shaft to become magnetized and set up a flux, Fig. 3, which flows out one bearing, through the frame of the machine, and in through the other bearing.

Since each axial element of the shaft within the confines of each bearing such as *MN* is a conductor which cuts the flux as shaft rotates, a potential difference is set up from *M* to *N* and from *P* to *Q*. This tends to produce a bearing current which flows from the shaft to one end of the bearing, axially along the bearing and back from the other end of the bearing to the shaft.

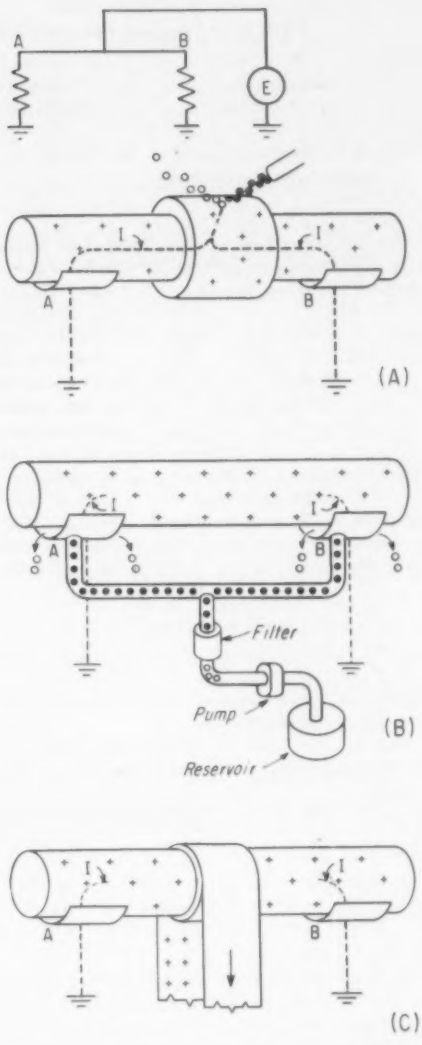

Fig. 4—Electrostatic effect and corresponding electrical circuit. (A) Potential developed by impinging particles. (B) Potential developed by charged lubricant. (C) Potential developed by charged belt. All cause bearings currents.

Electrostatic effect. In this effect, charges build up on the shaft, which is insulated by the oil film, until the potential is high enough to pierce the film. When this occurs, the charge is dissipated through the bearing causing a momentary flow of current. If the source of the charge is maintained, a process of alternate charging and discharging will continue indefinitely. Fig. 4 shows the various methods by which electrostatic charges can be built up.

1. *Potentials developed by impinging particles.* Under equilibrium conditions, each particle of a finely divided material has equal numbers of plus and minus charges and is, therefore, electrically neutral. When a stream of such neutral particles strikes an object under proper conditions, a portion of them rebound charged, either plus or minus, each leaving charges of the opposite sign on the struck object. The number of particles which become charged, the relative amounts of plus and minus charges in the stream, and the distribution of the charges in the stream depend upon the properties of the materials involved and upon the conditions under which impact takes place.

TABLE I—Principal Sources of Bearing Current and Methods of Current Control

TYPE	SOURCE OF BEARING CURRENT	LOCATION OF POTENTIAL DIFFERENCES	TYPE OF CURRENT	METHOD(S) OF CURRENT CONTROL
Fig. 1	Potential Applied to Shaft Intentional or accidental application of potential to shaft.	Between shaft and each bearing.	Ac or dc depending upon source	a) Insulate all bearings or b) Ground shaft.
Fig. 2	Dissymmetry Effect Variation of flux with angular position of shaft due to magnetic dissymmetry in machine.	a) Between extremities of shaft. b) Between each bearing and the shaft. (Checking for the possibility of this type of bearing currents by measuring potential difference between the shaft and one bearing not always reliable, see text. Better to check between extremities of shaft).	Ac, Frequency depending upon construction and speed of machine.	a) Insulate one bearing. If one bearing of a machine generating bearing currents is insulated and if the shaft on that end of the machine is metallically connected to the shafts of other machines, all bearings of the other machines should be insulated. or b) Ground both ends of shaft.
Fig. 3	Shaft Magnetization Effect (Also referred to as Homopolar Effect) Unbalanced dc or ac ampere-turns encircling shaft causing axial magnetization of shaft.	a) Between points on the shaft located at opposite ends of each bearing. b) Between each end of each bearing and its journal	Dc or ac depending upon frequency in ampere turns.	a) Balance ampere turns by addition of neutralizing coil. or b) Increase reluctance of magnetic circuit by substituting nonmagnetic material for magnetic material in bearing support. or c) Ground both ends of each journal.
Fig. 4 (A)	Electrostatic Effect Potential developed by impinging particles.	Between shaft and each bearing.	Dc, Measurments apt to be erratic—see text.	a) Insulate all bearings for high voltage or b) Ground shaft.
(B)	Potential developed by charged lubricant.	Between shaft and each bearing	Dc, Measurements apt to be erratic—see text.	Ground shaft and all bearings.
(C)	Potential developed by charged belt.	Between shaft and each bearing.	Dc, Measurements apt to be erratic—see text.	a) Insulate all bearings for high voltage. or b) Ground shaft.

in contact. If the particles are not uniformly distributed in the stream and if the surface is so located that it comes in contact with more positive than negative charges, for example, such a surface will become positively charged.

Machine parts sometimes become charged either by the process of charging neutral particles or by the process of contacting particles already charged. These charges occasionally are dissipated through the bearings. Some of the more common causes, Fig. 4(A), are charges that result from moisture particles in wet steam and from dust particles that impinge upon the parts.

2. *Potentials developed by charged lubricant.* Since most lubricants are relatively poor conductors, their individual molecules behave electrically similar to particles of finely divided material. Thus, passing a lubricant through certain types of filters with small passages results in the molecules of the lubricant becoming charged.

Since the lubricant is essentially a nonconducting medium, some of the molecules may remain charged even after passing through a considerable length of grounded pipe. Charges transported in this way may be deposited on a journal, Fig. 4(B), or on the bearing if the bearing is insulated. When the potential becomes high enough, the charge may be dissipated through the oil film.

3. *Potentials developed by charged belts.* Belt driven machines may be a source of electrostatic potential. As belts usually are poor conductors, charges developing at one pulley may be carried on the belt and deposited upon the other pulley. If the conditions at both pulleys are the same, a balance exists and no charge develops.

However, if the conditions are different and if the shaft is insulated by an oil film, a charge may build up on the shaft. The charge so collected, Fig. 4(C), may be dissipated through the bearing.

CHECKING FOR BEARING CURRENT

For bearing current to flow, it is necessary to have a potential difference between the journal and the bearing. The tendency for the formation of current in a bearing can, therefore, be detected by measuring the magnitude of the potential difference. Whether a current will flow under a given potential difference will depend on the thickness and resistivity of the oil film. Since both the film-thickness and the resistivity vary between machines

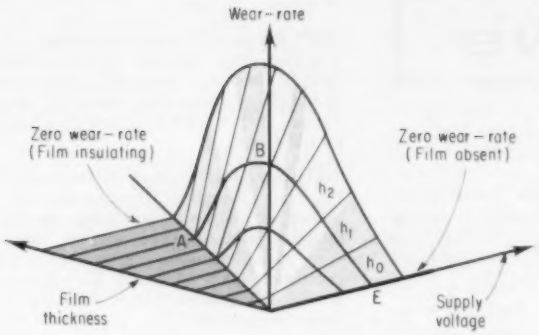

Fig. 5—Influence of film-thickness and voltage on the wear-rate caused by electrical pitting. Any change in film-thickness will alter the wear-rate and reduce bearing damage.

and change with operating conditions, hard and fast rules for allowable potential are impossible. Values found to be generally satisfactory in practice can, however, be given.

No single method of measuring potentials is suitable in all cases since a variety of conditions may produce bearing current. Table I shows the best location for taking a measurement to measure potential.

The difference between the types of effects involved also precribes different types of measuring instruments. Voltmeters having resistances of 1000 ohms per volt are usually satisfactory for most potentials except those caused by electrostatic effects. Here, an electronic or electrostatic voltmeter should be used.

In measuring the potential between the journal and the bearing, a limit of 100 mv is a satisfactory criterion for ordinary electrical apparatus. Since ball and roller bearings are usually more susceptible to damage from bearing currents, a 75 mv limit is set.

Measuring the potential between the shaft and one bearing may be unreliable for dissymmetry effect. Both bearings, in this instance, are in series with the generated emf and a temporary large resistance in the one bearing may make the potential across the other bearing negligible. Most reliable method is to measure the potential between the extremities of the shaft. A limit of 300 mv is a satisfactory criterion on ordinary electrical apparatus. Corresponding value is 100 mv for ball and roller bearing.

Electrostatic effects are influenced by humidity and surface conditions. Measurements are often extremely erratic and the absence of an electrostatic potential at the time of measurement does not mean that a potential will not exist under other conditions. Normally, sustained currents of large magnitude are not produced. However, the intermittent charging and discharging can produce enough bearing damage to cause failure.

The erratic nature of electrostatic potentials makes it difficult to set practical operating limits. It is known that peak voltages as high as 20 v can produce bearing damage. Reducing the voltage to about one volt by some form of grounding device ordinarily eliminates the trouble.

ELIMINATING OR REDUCING DAMAGE

It is obvious that one method of eliminating bearing currents is to remove the source. This solution may require drastic redesign of the apparatus which may not be practical or possible. The method used depends upon the cause of the current. Table I indicates some methods.

Insulating machine parts. Insulating a bearing requires that all connections to the bearing, such as oil lines and others, be considered. No metallic contact should exist between the bearing and its support or any surrounding conductors.

Grounding shaft. The cause of the current must be considered when grounding a shaft. A relatively simple brush arrangement may be adequate to lead-off and prevent the accumulation of an electrostatic potential.

Dissymmetry and shaft magnetization effects, however, produce low voltages and high currents. A high contact resistance brush would be ineffective; hence, brushes with low contact resistance and ample capacity are used.

Modifying machine design. Two methods of eliminating or reducing shaft magnetization effect may be used besides grounding. Since large currents may be involved if a large number of ampere-turns are present, the effect may be reduced by introducing neutralizing ampere-turns. If this is not practical, increasing the reluctance of the magnetic circuit through the bearing supports and frame by the use of nonmagnetic material may be possible.

ADDITIONAL MEANS OF REDUCING DAMAGE

Electrostatic effects can be minimized by bleeding off the charge as it is formed. This prevents the build up of dangerous potentials. Rendering the oil more conducting by the addition of additives or ionizing the surrounding atmosphere to conduct the charge are also suggestions, although neither method has been widely used.

Another method is based upon the fact that the wear due to electrical pitting depends upon film thickness as well as voltage. Fig. 5 shows that for every voltage, *E*, there is a maximum wear-rate, *B*, which occurs at some particular value of film thickness. If a bearing is operating in the vicinity of *B*, reducing the film thickness to about *E*, or increasing the film thickness to about *A*, will reduce or eliminate the wear rate.

Any change calculated to alter film-thickness such as varying the viscosity, changing the speed and load, or altering the amount of lubricant supplied may be used, provided it is consistent with the operating requirements of the bearing. As it may be difficult, in a given instance, to determine if operation is on or near the maximum wear rate, *B*, large changes in film thickness should be made to avoid the maximum wear region, or trial and error methods used to arrive at improved conditions.

REFERENCE:

The Causes and Control of Electrical Currents in Bearings by J. Boyd and H. N. Kaufman, Westinghouse Research Laboratories, Pittsburgh 35, Pennsylvania. Published in Lubrication Engineering, January 1959, p 28-35.

I ELECTRICAL AND ELECTRONIC COMPONENTS

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To obtain copies of literature described below, write prefix letter and number on reader service card.

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(I-2) Automation Components—Brochure, 16 pp. Photoelectric equipment, electronic timers and relays, synchronous contactors are described. Specifications, operation and price lists. Farmer Electric Products Co, Inc, 2300 Washington St, Newton Lower Falls, Mass.

(I-3) Switches—Catalog, 12 pp. Includes toggle, push, push-push, slide, rotary, snap and momentary types. Part numbers and ratings are given. Carling Electric, Inc, 505 New Park Ave, West Hartford 6, Conn.

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(I-16) Germanium Diodes—Bulletin, 24 pp. Specifications, electrical and physical characteristics of different subminiature point-contact germanium diodes, plus description of production facilities. Erie Resistor Corp, 644 W 12th St, Erie, Pa.

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ELECTRICAL AND ELECTRONIC COMPONENTS I

engineering information. Barber-Colman Co, Electrical Components Div, Rock St, Rockford, Ill.

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(I-55) Heaters—Catalog, 51 pp. Prices, specifications, ratings, selection and ordering information for immersion, cartridge, tubular, and other types. General Electric Co, 901 W Burlington Ave, Western Springs, Ill.

(I-56) Electrical Connectors—Catalog, 88 pp. Includes description of production facilities, services and listing of products: plugs, connectors, receptacles and others, along with their dimensions and specifications. Amphenol Connector Div, Amphenol-Borg Electronics Corp, 1830 S 54th Ave, Chicago 50, Ill.

(I-57) Insulated Wire & Cable—Brochure, 4 pp. Contains description, specifications and characteristics of 1000 F flexible wire and cable, silicone rubber insulated single and multi-conductor cable, coaxial and others. Boston Insulated Wire & Cable Co, 65 Bay St, Boston, Mass.

(I-58) Relays—Catalog, 8 pp. Describes line of control relays with sectional pole construction. Includes construction features, dimensions, and catalog numbers. The Clark Controller Co, 1146 E 152nd St, Cleveland, Ohio.

(I-59) Synchro Devices—Brochure, 15 pp. Provides information on rated accuracy, synchro system operation, performance, dimension data and others as well as applications and ordering. General Electric Co, Schenectady 5, NY.

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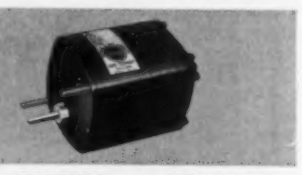

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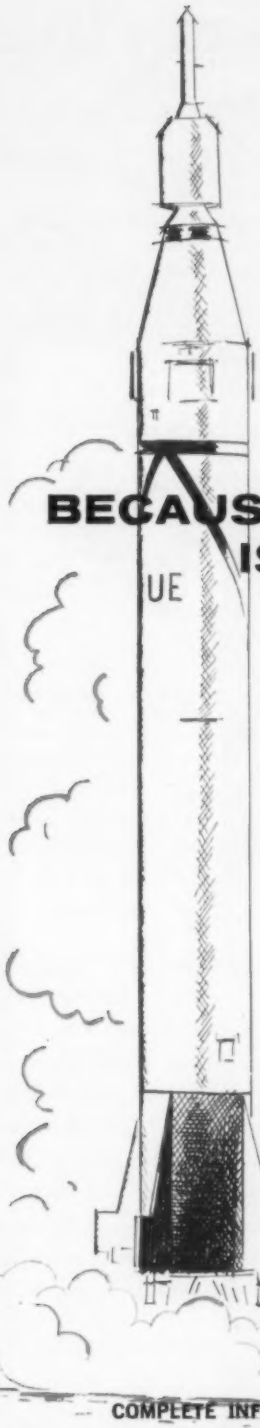

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- connector can be electrically disengaged without mechanical separation
- five indexed positions to permit strain-free cable exit
- identical inserts and contacts in both halves
- polarized to prevent improper coupling—has numbered cavities to assure proper circuit identification

COMPLETE INFORMATION ON THESE FOUR PRODUCT LINES IS AVAILABLE ON REQUEST.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

I ELECTRICAL AND ELECTRONIC COMPONENTS

Do you need a small switch with a high current-carrying capacity? ...*Acro offers a 10 Amp Miniature and Sub-Miniature Switch.*

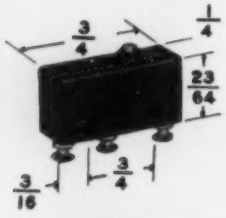
When space, or lack of it, is a stumbling block in your product, Acro miniature and sub-miniature switches can provide a quick solution to your problem.

For Acro miniature and sub-miniature switches carry loads from 3 to 10 amps!

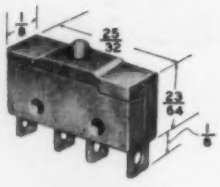
With Acro Miniature and Sub-miniature switches you get big switch performance, long mechanical life (many millions of actuations on most types), and excellent environment characteristics—resistance to extreme temperature and vibration.

Acro miniature switches are also easily ganged for muti-pole application, and are available with very light operating force.

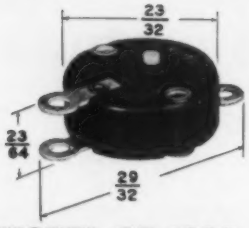
Acro Offers the Biggest Line of Little Switches



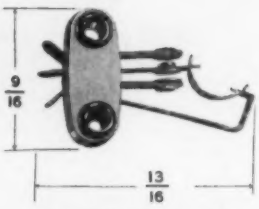
MODEL Z
(Sub-miniature)
High current-carrying capacity, long mechanical life. Designed for AC or DC applications. Available with roller leaf, or straight leaf, overtravel, and manual pushbutton, and toggle actuator. RATINGS: 5 Amp. 120/240 VAC; 30 VDC



MODEL SM
(Sub-miniature)
Up to four times the capacity of other switches, all packed in an assembly that's less than one inch long! Approved by UL for 10 amps, 125-250 volts AC, and 10 amps, 28 volts DC. Double circuit terminals are standard on both normally open and normally closed contacts.

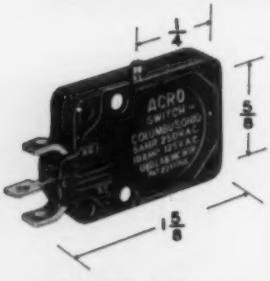


MODEL QD 1000
(Sub-miniature)
Low-cost precision switch, smaller than a dime. 10 amp capacity, works on a very light operating force. Available with disconnect terminals, panel mount, overtravel plunger also provided.

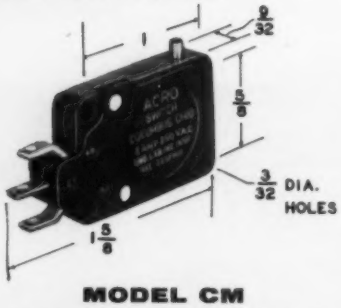


MODEL M-OM
(Sub-miniature)
Here's a real sub-miniature switch — extremely small in size, with an unusual configuration that makes it a real space-saver. Carries a 3 amp load at 125 VAC. Can also be ganged for multi-pole circuitry.

Acro's Miniature Switches



MODEL M
A giant in capacity — a Tom-thumb in appearance. Carries full 10 amps, mechanical and electrical life measured in millions of actuations. Easily ganged for multi-pole circuitry, wide variety of external actuators available.



MODEL CM
Can be actuated by extremely light operating pressures, as low as 20 gms. Can be ganged for multi-pole requirements. Ideal for coin-operated devices or timers. Unlimited variety of actuators available. Rated at 3 amp, 125 VAC.

● No matter what your switching problem — from the miniature and sub-miniature switches shown here — to rugged giants that carry he-man loads — Acro is the source for a quick solution to your problem. Take advantage of Acro's free engineering service. Just write — telling us what you want a switch to do, where it has to fit — and how — and we'll get right to work on it for you. No obligation, of course.

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Manufacturers of a complete line of load-tested precision snap-switches and relays

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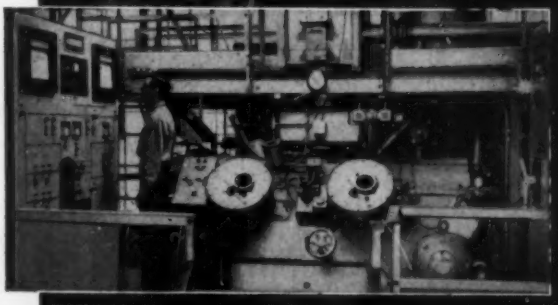

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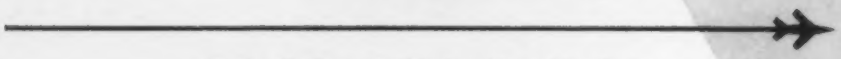

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Thanks to a wealth of experience gained in providing dependable, uniform, controlled heat for industry and the military, SAFEWAY today produces heating elements for a thousand and one different applications.

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Indicated at the right are a representative few of the myriad applications considered "routine" for SAFEWAY.

If it has to be heated—(and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and—without obligation—submit an appropriate recommendation.

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1649 TIMERS

that **SOLVED** special control problems.

• How this engineering experience can help you.

The small Time Delay Timer represents one of the simplest motor driven timers we manufacture. It is a reliable standard fixed time delay type.

Industrial Timer also manufactures this Punched Tape Programmer which controls 85 individual load circuits through an unlimited number of steps. No coding or elaborate memory systems are required, making possible direct control from Programmer to process.

Between these two extremes we list 1688 different timers, of which 39 are standard types and 1649 are "specials" developed to solve difficult control problems.

Most timing problems have their own unique characteristics. However, it very often happens that a control problem is quickly solved by one of these 1649 already developed special timers. If not, we have the staff, the experience (20 years) and what's more important, the desire to design and deliver the timer that fills your needs 100%. Send us your specifications.

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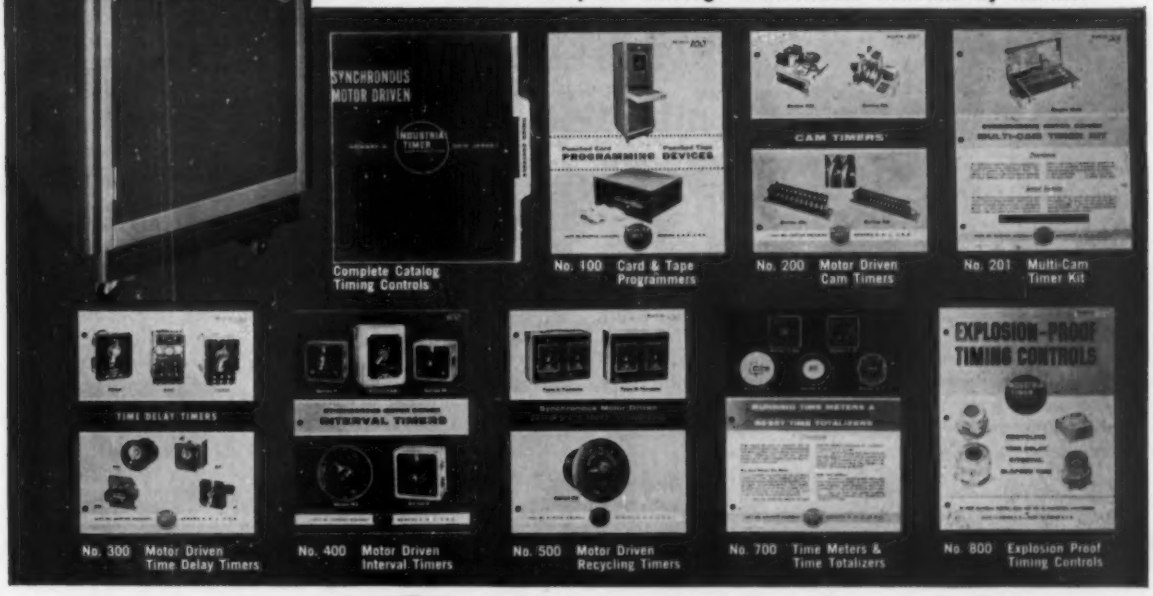
Ask for complete catalog or individual bulletins by number



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No. 100 Card & Tape Programmers

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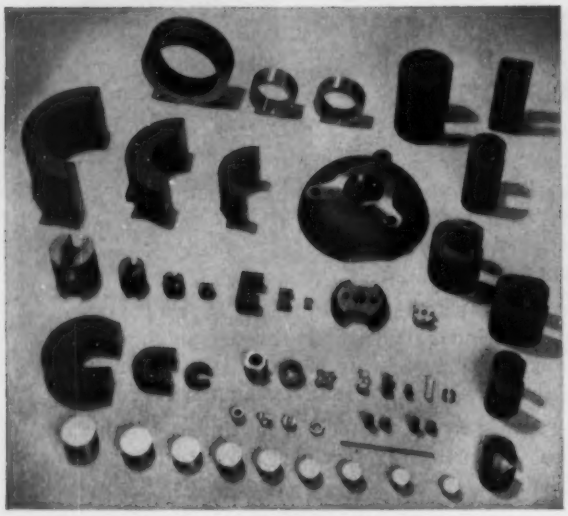
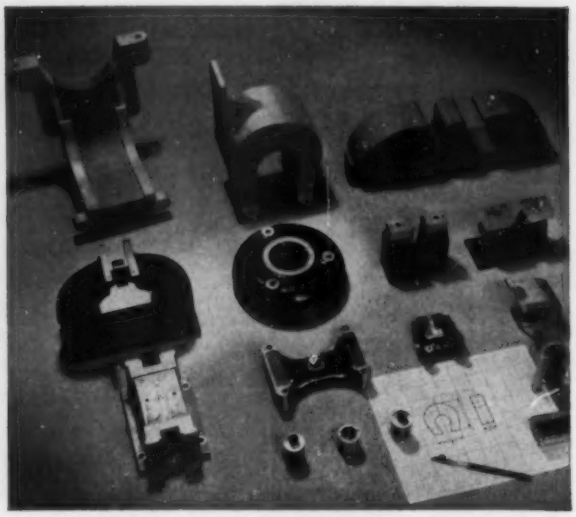
AFFILIATE—LINE ELECTRIC COMPANY

Specify "ARNOLD" for your PERMANENT MAGNET requirements



Typical group of Arnold permanent magnets, both cast and sintered types.



Typical group of permanent magnet assemblies, aluminum jacketed.

ALNICO MAGNETS

Arnold permanent magnets are available in all types of Alnico material, in sizes ranging from large castings weighing over 80 pounds to very small sintered parts weighing less than one gram.

Alnico V can usually be depended upon to deliver the greatest energy product to the magnetic circuit per unit weight of magnet material. It is therefore generally the first choice for a magnetic material except where special physical considerations are paramount.

Special assemblies such as rotors, traveling wave tube magnets, magnetron magnets, etc. may be supplied in an aluminum jacket to facilitate mounting and supply an added protection to the magnet.

Large magnet assemblies may also be supplied for mass spectrometer and other measuring applications where a high degree of stability and uniformity of field is required.

Many sizes and types of Alnico magnets are carried in stock for immediate delivery. For more information, *write for Bulletin GC-106C.*

SPECIAL PERMANENT MAGNET MATERIALS

ARNOX III

Arnox III is a molded-type magnet having high coercive force and moderately low residual induction and energy product. Principal uses are for magnetic requirements which are not stringent, and for a relatively short magnet of reasonable cross section. Accurate dimensions and close tolerances can be economically obtained. These magnets can be premagnetized before assembly, and have very high resistance to demagnetization. Slightly better magnetic properties are obtained in the pressing direction than in other directions.

ARNOX V

Arnox V is a ceramic permanent magnet material composed of highly oriented barium ferrite. It has many times the energy product of Arnox III and is comparable in many applications to Alnico V. Because of its high coercive force, its use is recommended in applications where a short magnetic length is desirable or where extremely high demagnetizing forces may be encountered. In many applications, it may be magnetized prior to assembly.

VICALLOY

Vicalloy is a carbon-free permanent magnet alloy containing about 10% vanadium, 50% cobalt and the balance iron.

Vicalloy may be fabricated in the form of castings, hot rolled bars and forgings, or cold rolled strip, wire and tubing. After suitable heat treatment, the material is quite readily machinable. Vicalloy is available on special order in bar, strip and thin tape for recording purposes. *For more information, write for "The Magneteer," Vol. 2, No. 1.*

CUNIFE

Cunife is a permanent magnet alloy of copper, nickel and iron which is malleable, ductile and machinable, after final heat treatment. The magnetic properties of Cunife are developed by cold working and are directional, with the best magnetic properties found only in the smaller sizes of rods or wires.

WSW 7806

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No chain of explosion-proof electrical devices is stronger than its weakest link.

Crouse-Hinds — and only Crouse-Hinds — can provide positive protection *wherever* the merest spark can possibly occur in explosive atmospheres . . . from size 5 motor starters to sound-powered telephones. There are over 15,000 conventional and explosion-proof products in the Condulet line! They are available through your Crouse-Hinds distributor.

For further assistance on your explosion-proofing problem, just call the nearest Crouse-Hinds office listed below. Our field engineers are *electrical* engineers, fully qualified to make specific recommendations for your plant.

CROUSE-HINDS COMPANY

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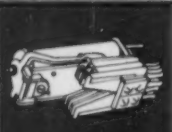
WRITE 489 ON READER SERVICE CARD

AUTOMATIC ELECTRIC

AE RELAYS

	SERIES	OPERATING TIME, SECONDS	*RELEASE TIME, SECONDS
CLASS B When extremely long service and reliable operation are demanded, this relay meets the requirements. Life often exceeds 400 million operations. Ideal for computers, fire control, pulsing or switching functions.	BQA	0.002-0.030	0.005-0.050
	BSO	0.040-0.120	0.025-0.350
	BSR	0.004-0.035	0.035-0.600
	BSA	0.020-0.055	0.035-0.600
	BFA	0.010-0.025	0.008-0.020
	BMS	0.010-0.030	0.015-0.050
CLASS E A new telephone-type relay, designed for long-life industrial service. Based on the rugged Class B design, this is a universal relay, engineered for a variety of uses demanding compact size coupled with our usual high standard of reliability.	EQA	0.002-0.030	0.005-0.025
	ESO	0.015-0.050	0.025-0.125
	ESR	0.005-0.030	0.025-0.125
	ESA	0.015-0.030	0.050-0.125
	EFA	0.005-0.025	0.005-0.025
	EMS	0.010-0.030	0.015-0.030
 **CLASS A** This original telephone-type relay will hold down costs, yet provide dependable operation and long life. A wide variety of coils, contacts, contact spring arrangements and mounting facilities makes this truly the "all-purpose" relay.	AQA	0.002-0.025	0.005-0.025
	ASO	0.040-0.120	0.020-0.250
	ASR	0.004-0.025	0.020-0.350
	ASA	0.010-0.050	0.020-0.350
	AWS	††Up to 2	0.005-0.025
	AVR	0.002-0.025	††1 to 15
	AMC	0.210-0.280	0.300-0.345
CLASS C This compact relay combines unusual dependability and surprisingly long service life in a space about half of the size of the average relay of equal rating. Can be used for high-speed or delayed operation.	CQA	0.005-0.035	0.005-0.025
	CSA	0.010-0.040	0.015-0.200
	CMS	0.010-0.035	0.010-0.050
CLASS S Specify this relay for aircraft use, where a small, light relay is required, resistant to shock and vibration. It features fast pulse response because of its small mass and slight self-inductance. Series SQPC available for printed circuits.	SQA	0.002-0.016	0.005-0.085
	SQD	0.002-0.030	0.005-0.085
	SQPC	0.002-0.030	0.005-0.085
	S-Power	0.005-0.016	0.005-0.010
CLASS Z Choose Class Z relays where a small, light relay is needed but long life or time delay is of greater importance than extremely small size. Similar to Class A relay, but smaller and less sensitive.	ZQA	0.002-0.025	0.005-0.025
	ZSO	0.010-0.050	0.050-0.150
	ZSR	0.003-0.010	0.050-0.200
	ZSA	0.010-0.040	0.050-0.200
	ZMS	0.010-0.040	0.005-0.200
	ZFA	0.010-0.025	0.008-0.020
	Type 18	0.002-0.025	0.005-0.025
CLASS F An a.c. relay, for use when the number of relays doesn't justify a rectifier, and when operate and release time delays are not a factor. When operate and release timing is required, an inexpensive rectifier can be used with any of the above d.c. relays.	FQA	0.002-0.025	0.005-0.040
	BFA	0.010-0.025	0.008-0.020
	EFA	0.005-0.025	0.005-0.025
	FMS	0.002-0.020	0.002-0.020
	FMC	0.298-0.333	0.290-0.350
	ZFA	0.010-0.025	0.008-0.020
POLARIZED Series PHD and PLD offer "2-position" or "3-position" operation; Series PTW provides "2-position" only. "2-position" relays "stick" operated until current is reversed; "3-position" have neutral position in absence of current.	PLD	0.003-0.010	0.022-0.047
	PHD	0.006-0.027	0.065-0.075
	PTW****	0.007 Minimum	0.0002 Approx. Travel Time
SPECIAL PURPOSE—We can usually make assemblies of Automatic Electric relays with modifications to suit your special applications. The Class E Video relay, illustrated here, is an example. Others are designed for power applications, electro-mechanical interlocking, marginal operation, mechanical locking, micrometer adjusting, and the simultaneous closing of up to 35 circuits (BAR relay).			

AE STEPPING SWITCHES

FAST STEPPING, SMOOTH RUNNING, POSITIVE STEPPING

TYPE 44

The Type 44 is a small switch with a large, flexible capacity. Use this switch in almost any d.c. application—for impulse controlled response or self-interrupted operation. Though it's only slightly larger than a pack of king-size cigarettes, the Type 44 rotary stepping switch accommodates up to six 10-point bank levels.

TYPE 45

In every feature of its design, the Type 45 rotary stepping switch provides for adaptation to varied requirements, including a.c. operation. The one-piece, open-type flat frame occupies only one side of this switch, so the 25-point contact banks can be built up level by level as needed, up to twelve.

SERIES OCS RELAY

Here's a shock-resistant relay which can be used for cam-switching...for alternate on-off operations...or as a "stepper." When you order Automatic Electric's OCS relay, you specify the programming. This compact unit simplifies engineering and wiring—cuts space, weight and maintenance costs.

RELAYS **SWITCHES**

AUTOMATIC ELECTRIC

SERIES	MAXIMUM COIL VOLTAGE	MAX. NO. OF STANDARD CONTACTS	TYPE OF CONTACTS†††	WEIGHT	DIMENSIONS (MAX.) IN.
BQA	250 dc	24 Spgs.		8-12 oz.	4-3/32x2-5/16x1
BSO	135 dc	**24 Spgs.		8-14 oz.	4-3/32x2-5/16x1
BSR	135 dc	*6 Spgs.	Code 0—18 ga.	8-14 oz.	4-3/32x1-7/8x1
BSA	250 dc	*6 Spgs.	Twin	8-14 oz.	4-3/32x1-7/8x1
BFA	230 ac	24 Spgs.		8-14 oz.	4-3/32x2-5/16x1
BMS	250 dc	***2 Form C	Snap-action	7-11 oz.	4-3/32x2-17/32x1-23/32
EQA	150 dc	26 Spgs.			
ESO	110 dc	26 Spgs.			
ESR	110 dc	*6 Spgs.	Code 0—18 ga.	2-3 oz.	2-1/4x1-23/32x1-1/8
ESA	110 dc	*6 Spgs.	Twin		
EFA	220 ac	12 Spgs.			
EMS	150 dc	2 Form C	Snap-action		2-1/4x1-23/32x2-3/16
AQA	250 dc	26 Spgs.		8-12 oz.	4-3/32x2-3/16x1-7/16
ASO	135 dc	26 Spgs.		8-14 oz.	4-3/32x2-3/16x1-7/16
ASR	135 dc	*6 Spgs.		8-12 oz.	4-3/32x2x1-7/16
ASA	250 dc	*6 Spgs.	Code 4—18 ga.	8-12 oz.	4-3/32x2x1-7/16
AWS	250 dc	1 Form A		7-11 oz.	4-3/32x2-3/4x1-7/16
AVR	250 dc	Special		8-12 oz.	4-1/4x2x1
AMC	250 dc	2	Mercury	12-16 oz.	4-3/4x3-1/16x3
CQA	150 dc	12 Spgs.	Code 0—18 ga. Twin	4-oz.	4-1/32x2-3/16x21/32
CSA	150 dc	12 Spgs.	Code 0—18 ga. Twin	4-oz.	4-1/32x2-3/16x21/32
CMS	150 dc	1 Form C	Snap-action	6-oz.	3-13/16x2-7/16x1
SQA	†115 dc	9 Spgs.		2-oz.	1-17/32x2x11/16
SQD	†115 dc	18 Spgs.	Code 0—20 ga.	2- 3 oz.	1-17/32x2x1
SQPC	†115 dc	18 Spgs.	Twin	2- 3 oz.	1-17/32x2x1
S-Power	115 dc	1 Make	Silver-Tungsten	12 oz.	1-1/2x1-1/2x1-1/4
ZQA	135 dc	13 Spgs.		4- 6 oz.	2-1/2x2-3/4x1-1/2
ZSO	115 dc	13 Spgs.		4- 6 oz.	2-1/2x2-3/4x1-1/2
ZSR	115 dc	*6 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-3/4x1-1/2
ZSA	135 dc	*6 Spgs.		4- 6 oz.	2-1/2x2-3/4x1-1/2
ZMS	135 dc	***2 Form C	Snap-action	8-10 oz.	2-1/2x2-5/8x2-1/4
ZFA	115 ac	13 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-3/4x1-5/16
Type 18	12 or 24 dc	10 Spgs.	Code 9—18 ga.	4- 6 oz.	2-1/2x2-1/4x1-1/4
FQA	To 230 (16-66 cycles)	12 Spgs.	Code 4—18 ga.	9-13 oz.	4x1-15/16x1-1/4
BFA	To 230 (20-60 cycles)	24 Spgs.	Code 0—18 ga.	8-14 oz.	4-3/32x2-5/16x1
EFA	To 220 ac	12 Spgs.	Code 0—18 ga.	2- 3 oz.	2-1/4x1-23/32x1-1/8
FMS	To 240 (16-66 cycles)	2 Form C	Snap-action	10-14 oz.	3-1/2x2-3/8x2-3/8
FMC	To 240 (16-66 cycles)	2	Merc.-Glass	14-18 oz.	4-5/8x2-3/4x2-3/4
ZFA	To 115 (20-60 cycles)	13 Spgs.	Code 4—18 ga.	4- 6 oz.	2-1/2x2-7/8x1-11/32
PLD	350 dc	6 each side	Code 4—18 ga.	28 oz.	4x3-1/4x2
PHD	350 dc	6 each side	Code 4—14 ga.	27-37 oz.	4-13/16x2-3/4x3
PTW****		1 Form C	Tungsten Carbide or Palladium	14 oz.	2-7/8x2-1/4x3-5/16

*More contacts can be used at a sacrifice of speed.
**Up to 0.600 sec. release time on BSO relay with 6 springs max.
***With 1 snap-action switch and 1 contact assembly (8 springs max.)
****Octal or pin-type plug (to fit WE Co. 255 applications) available.
†Higher wattage obtainable with oversize coils.
††Timing value in conjunction with a Series ASO relay.
†††Most relays can be furnished with special heavy-duty contacts.

Automatic Electric, pioneer in the use of telephone-type relays for industry, has the experience, reputation, manufacturing facilities, research staff, and down-to-earth, practical "know how" to solve your knottiest control problem. We specialize in the hermetic sealing of relays and switches, as well as in the design, circuitry and assembly of industrial control "packages" and systems. Our representative and facilities are at your command.

SALES REPRESENTATIVES

ALEXANDRIA, VA.
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ORLANDO, FLA.
ROCHESTER, N.Y.
SAN FRANCISCO, CALIF.
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*District Office

Check the Yellow Pages of your telephone directory to get in touch with our representative in your area. Address all Home Office inquiries to: Director, Industrial Control and Equipment Sales.

We will be happy to send additional literature on request. You may be interested in some of the following:

Rotary Stepping Switches.....#1698-H
Relays for Industry.....#1702-E
Relay Terms.....#1884
Basic Circuits.....#1927
Hermetically Sealed Components.....#4083
Key Switches and Other Electrical Control Components.....#4018-E

Address requests to:
Director, Industrial Control and Equipment Sales, Northlake, Illinois

RELAYS **SWITCHES**

AUTOMATIC ELECTRIC

Subsidiary of GENERAL TELEPHONE

Distributors in U.S. and Possessions:

AUTOMATIC ELECTRIC SALES CORPORATION

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Export Distributor: Automatic Electric International, Incorporated, Northlake, Illinois.

WRITE 491 ON READER SERVICE CARD 491

GRAPHALLOY

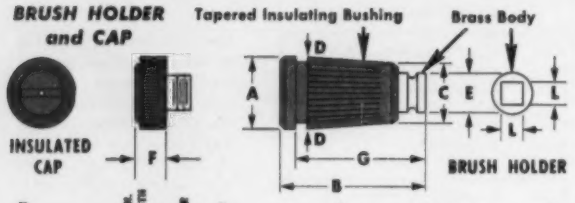
SILVER GRAPHALLOY BRUSHES and BRUSH & SLIP-RING ASSEMBLIES . . .

GRAPHALLOY BRUSHES

are used on such equipment as . . . SERVO SYSTEMS • SYNCHROS • CHOPPERS • RADAR • GYROS • INVERTERS • THERMOCOUPLE and STRAIN GAGE CIRCUITS • GUIDED MISSILES • PULSE SYSTEMS • DIGITAL COMPUTERS • WAVE GUIDES • SONAR • TRANSDUCERS • TORQUE INDICATORS

Silver GRAPHALLOY Brushes have been widely used because *of* LOW *and* CONSTANT CONTACT DROP, EXTREMELY LOW ELECTRICAL NOISE *and* LONG LIFE. Over 200 grades are now serving in a wide variety of applications. Silver GRAPHALLOY Brushes on ½"-diameter coin silver slip rings have operated successfully in highly critical electrical circuits at speeds up to 100,000 R.P.M. *Our Engineering Department will assist in determining the exact grade of* GRAPHALLOY *for your needs.* Ask for our Brush Inquiry Form 109.

BRUSH HOLDER and CAP



BRUSH HOLDER & CAP NO.	BRUSH SIZE	SUGGESTED MIN. SLIP-RING WIDTH	**MOUNTING HOLE DIAMETER	BRUSH HOLDER TO SLIP RING	A	B OVERALL LENGTH	F	C	D	E	G	L BROACHED HOLE
14326	⅛" sq.	3/16"	13/32"	1/16" min.	.437"	⅞"	3/16"	.404"	.418"	.281"	25/32"	.129"
11509†	5/32" sq.	3/16"	13/32"	1/16" min.	.437"	⅞"	3/16"	.404"	.418	.281"	25/32"	.160"
11570†	3/16" sq.	¼"	7/16"	1/16" min.	.484"	⅞"	3/16"	.441"	.451"	.313"	25/32"	.192"
11527†	¼" sq.	5/16"	9/16"	⅛" min.	.616"	1 5/16"	3/16"	.561"	.573"	.438"	1 3/16"	.256"

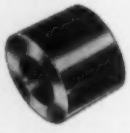
†Shunts are provided. **Mounting hole diameter for brush holder dimension D.

Request and fill in Brush Inquiry Sheet, Form 109, so that we can supply the proper grade of brush material.

BRUSH ASSEMBLIES

GRAPHALLOY, because of its inherent, non-welding and arc-quenching characteristics, is used widely for contacts . . . especially where positive breaking of a circuit is required.

BUSHINGS Oil-free



Replace oil-lubricated bushings in synchros, instruments, timers and missiles.

Advantages: 1) Lower friction at room temperatures. 2) No oil to solidify at low temperatures. 3) No oil to carbonize at prolonged elevated temperatures.

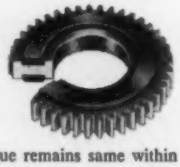
*Ask for Data Sheets 270 and 277 on Miniature Bronze-*GRAPHALLOY *Bushings.*

CONNECTORS (garter springs)

These silver-plated coil spring Connectors make for positive electrical connection to the brass body of the brush holder by snapping into the groove on the holder. The connecting lead can be pre-soldered to the Connector.

GARTER SPRING CONNECTORS	BRUSH SIZE	BRUSH HOLDER NO.
127-9	⅛" sq.	14326
127-9	5/32" sq.	11509
127-10	3/16" sq.	11570
127-14	¼" sq.	11527

CLUTCH FACINGS and CLUTCH GEAR ASSEMBLIES



Torque remains same within close operating limits despite changes in temperature and humidity. For instrumentation, guided missiles, constant friction devices.

SLIP RINGS Solid Coin Silver

Standard Coin Silver Slip Rings, both *cylindrical* and *flat* types, are illustrated at right. We recommend the cylindrical type rings with three brushes per ring . . . spaced at 120°. The cylindrical type are designed for press fitting over standard steel shafting. The flat type rings are designed for nesting either on an insulated plate or for molding into insulation. Insulated slip rings of either type or slip-ring assemblies can be furnished with leads attached.

No. 168 Series flat type to 20" O.D.

Standard "Flat" rings have ¼" radial contact surface and ⅛" radial spacing between adjacent rings.

No. 116 Series cylindrical type to 36" O.D.

Copper Slip Rings, flat or cylindrical, are available.

Model 319 CYLINDRICAL SLIP-RING assembly

MODEL	RINGS	LENGTH
319-4	4	2 7/16"
319-6	6	3 5/16"
319-10	10	4 13/16"
319-14	14	6 5/16"

Slip-ring O.D. 1⅝". Terminal O.D. 4".
Assembly I.D.: .814"/.813"
Range: Same as for Model 399

Model 409 FLAT SLIP-RING assembly

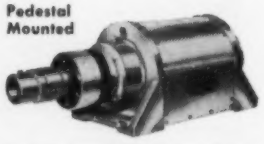
Solid Coin Silver Rings

MODEL	RINGS	OVERALL O.D.—"A"
409-2	2	5½"
409-4	4	7"
409-6	6	8½"
409-10	10	11½"

Hub O.D. 2"; I.D. 1.573"/1.571"; Length 1⅛". To 5 amperes, 125 volts.
More rings available upon application.

Model 399 BRUSH and SLIP-RING assembly

Pedestal Mounted



MODEL	RINGS	bolt slot distances CL to CL WIDTH	bolt slot distances CL to CL LENGTH	**OVERALL LENGTH
399-4	4	4½"	7¾"	13¼"
399-6	6	4½"	8½"	14"
399-10	10	4½"	10"	15½"
399-14	14	4½"	11½"	17"

**To outer end of coupling.

Specifications: Width 6½"—Height 6½". Shaft CL above base 3¼".
Applications: from strain gage or thermocouple up to 5 amperes, 125 volts, 250°F.
Speeds to 5,000 RPM.
Three Silver-GRAPHALLOY Brushes per solid coin silver slip ring.
Extraneous noise level extremely low.
Rugged in design and construction.
Readily connected mechanically and electrically.
Complete coupling provided for 15/16" shaft.
More rings and higher speeds available upon application.

Write for data sheets

CALL ON OUR OVER 40 YEARS OF DESIGN EXPERIENCE FOR HELP IN SOLVING YOUR BRUSH PROBLEMS!

GRAPHITE METALLIZING CORPORATION : 1011 NEPPERHAN AVENUE YONKERS, NEW YORK

STEMCO THERMOSTATS
for precise, sensitive temperature control

1, 2, TYPE C *semi-enclosed* (1), *hermetically sealed* (2). Small, positive acting with electrically independent bimetal strip for operation from -10° to 300°F. Rated at approximately 3 amps, depending on application. Hermetically sealed type can be furnished as double thermostat "alarm" type. Various terminals and mountings. Bulletin 5000.

3, 4, TYPE M *semi-enclosed* (3), *hermetically sealed* (4). Electrically independent bimetal disc types for appliance and electronic applications from -20° to 300°F. Rating: 8 amps at 115 VAC, 4 amps at 230 VAC and 28 VDC. Semi-enclosed with virtually any type terminal; hermetically sealed with pin or solder terminals, wire leads, various mounting brackets. Bulletin 6000.

5, 6, TYPE MX *semi-enclosed* (5), *hermetically sealed* (6). Snap acting miniature units to open on temperature rise for missile, avionic, electronic and similar uses. 2° to 6° differentials available. Rated at 3 amps to 1 amp, depending on duty cycle, at 115 VAC and 28 VDC for 250,000 cycles. Semi-enclosed types with metal or ceramic bases; hermetically sealed in circular or CR7 cans. Various terminals, mountings, brackets, etc. Bulletin 6100.

7, 8, TYPE S* *adjustable* (7), *non-adjustable* (8). Positive acting with single stud or nozzle mounting. Operation to 600°F. Rated at 15 amps at 115 VAC, 7 amps at 230 VAC. Spade, screw or elevated terminals, various adjusting stems, etc. Bulletin 1000.

9, TYPE SA* *adjustable* (9) *or non-adjustable.* Snap acting with electrically independent bimetal. Also single-pole, double-throw. Single stud or nozzle mounting. Non-inductive-load rating: 15 amps at 115 VAC, 10 amps at 230 VAC. Spade or screw terminals. Bulletin 2000.

10, TYPE SM* *manual reset* (10). Electrically same as Type SA (above) except for manual reset feature. Bulletin 2000.

11, TYPE B *adjustable* (11) *or non-adjustable.* For uses where heat generated by passage of current through bimetal strip is desirable. Various terminals, single stud or nozzle mounting. Operation to 400°F. Nominal rating: 5½ amps at 115 VAC of 40 cycles and higher. Bulletin 9000.

12, 13, 14, TYPE A* *semi-enclosed* (12, 13), *hermetically sealed* (14). Insulated, electrically independent bimetal disc gives fast response and quick, snap action control for appliance, electronic and apparatus applications from -20° to 300°F, or higher on special order. Rating: 3 to 4 amps, depending on duty cycle, at 115 VAC, 2 amps at 230 VAC and 28 VDC. Various enclosures and mountings, including brackets. Bulletin 3000.

15, TYPE R* *sealed adjustable* (15), *sealed non-adjustable.* Positive acting for operation to 600°F. Rated at 15 amps at 115 VAC, 4 amps at 230 VAC. Screw terminals. Bulletin 7000.

16, TYPE W* *adjustable* (16), *or non-adjustable.* Snap action bimetal strip type for operation to 300°F. Rated at 5 amps at 115 VAC, 3 amps at 230 VAC. Screw or nozzle mountings; spade, solder or screw terminals. Bulletin 4000.

17, TYPE H† *adjustable.* Positive acting for fry pans, skillets, sauce pans, etc. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 VAC. Bulletin 10,000.

18, TYPE D* *automatic* (18), *or manual reset.* For laundry dryers or other surface and warm air applications. Snap acting disc type U.L. approved for operation to 350°F. Open or enclosed styles. Rated at 25 and 40 amps at 120-240 VAC. Screw or spade terminals. Bulletin 8000.

Illustrations, for general information only, do not necessarily show size comparisons. Fully dimensioned and certified prints on request. Manufacturer reserves right to alter specifications without notice. AA-7230

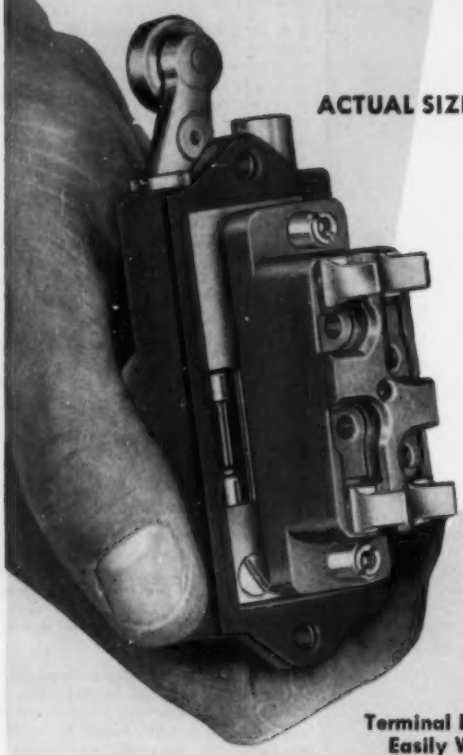
*Refer to Guide 400 EB for U.L. or C.S.A. approved ratings.
†Patent Applied For.

STEVENS *manufacturing company, inc.*
P. O. Box 1007, Mansfield, Ohio

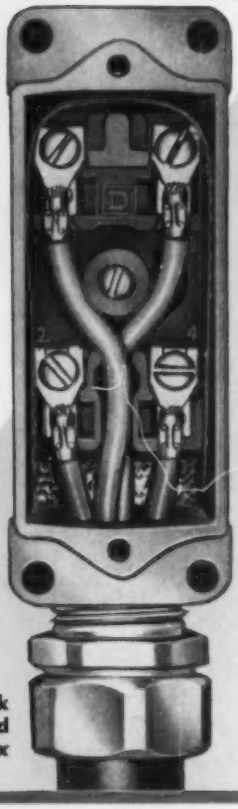
STEMCO ®
THERMOSTATS

This New PLUG-IN LIMIT

CLASS 9007, TYPE AW



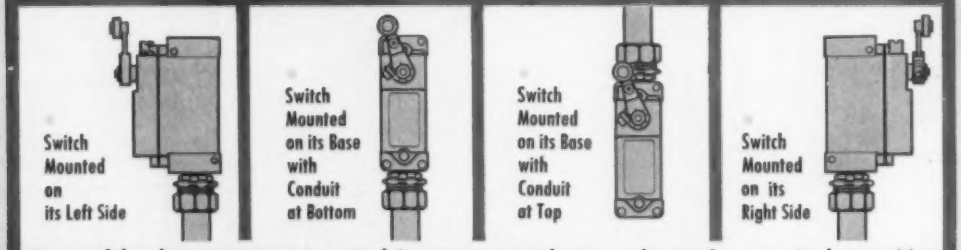
ACTUAL SIZE



Terminal Block Easily Wired *Without Removing from Box*

- Oil-tight construction
- Switch plugs in—in seconds
- Mounts without disassembly
- Wired without removing from box
- Reversible plug-in unit —can be plugged-in with roller arm at either end
- Switch action can be reversed by simple screwdriver adjustment
- Present installations easily converted to plug-in
- Precision switch mechanism —only 5° to operate— 25°overtravel in either direction
- Graduated markings around hub of roller arm simplify accurate settings
- Same price as standard Square D oil-tight limit switch

6 MOUNTING ARRANGEMENTS...WITH 1 DEVICE!


Switch Mounted on its Left Side
Switch Mounted on its Base with Conduit at Bottom
Switch Mounted on its Base with Conduit at Top
Switch Mounted on its Right Side

In any of the above arrangements, conduit can enter at either top or bottom by reversing box position

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SWITCH is SO EASY to Use!

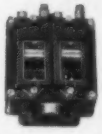
SQUARE D LIMIT SWITCHES ARE Designed TO DO HUNDREDS OF JOBS — BETTER!

SMALL OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE AW

Surface mounting, roller arm operated

Flush mounting, push rod operated

Surface mounting, push rod operated

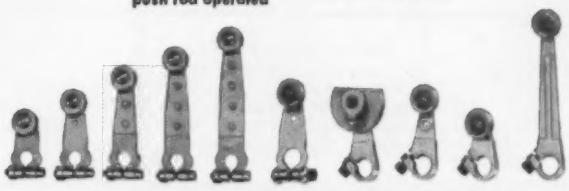


Duplex switch, surface mounting, push rod operated

Duplex switch, flush mounting, lever arm operated

Flush mounting, lever operated

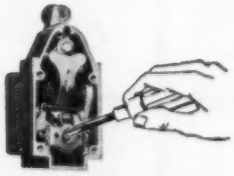
ROLLER ARMS AVAILABLE IN WIDE RANGE OF DESIGNS AND LENGTHS...



HEAVY-DUTY OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE T

Continuously adjustable lever arms, up to 80° overtravel

Transparent plastic cover available for instant inspection



Eleven contact arrangements in one switch; only a screwdriver is required

Rear shaft design for inaccessible locations

Many sizes and types of operating arms

WIDE VARIETY OF BASE PLATES AND MOUNTING HOLES...

Write for BULLETIN 9007 AW to Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

I ELECTRICAL AND ELECTRONIC COMPONENTS

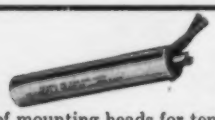
Fenwal Precision Temperature Control and Detection Devices

CONTROL ELEMENTS OF THERMOSWITCH® UNITS

In Standard Types and Sizes, also Midget and Miniature Units, control is based on a simple and unique differential expansion principle. A single-metal shell always in direct contact with the medium being controlled, contracts or expands instantly with temperature changes, making or breaking totally enclosed electrical contacts.

In Snap-Action Units, control is provided by an expandable liquid acting on a bellows assembly. The bellows motion, actuated by volume changes of the liquid, operates the switch contacts through a push rod. In Fenwal units, the liquid is outside the bellows, adjacent to the shell, for shorter heat transfer path and greater sensitivity.

In all Units each control setting is easily adjustable. High resistance to shock and vibration is characteristic, together with hermetic-sealing and many different temperature ranges.



INDUSTRIAL UNITS

A standard, cartridge type THERMOSWITCH unit. Compact, self-contained in a wide variety of mounting heads for temperatures ranging from −100°F to +400°F, or −100°F to +600°F. Also furnished in higher ranges. Bulletin MC-177.

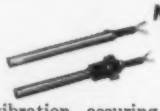
ELECTRONIC CONTROLLERS

Thermistor Indicator Controller (Series 560). For industrial or laboratory applications. Sensitivity 0.25% of scale range. Temperature ranges −100°F to +600°F. Proportional and on-off control. Bulletin MC-140.

Unit Thermistor Controls (Series 535). For all modern control equipment, systems and processes. Utilizes temperature-resistance property of thermistors in transistorized circuit for precise control and reliability. Bulletin MC-179.

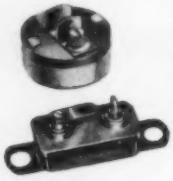
SNAP-ACTION UNITS

Single and Dual Types. Single has one snap-switch, dual has two. For high current applications, controls loads up to 20 Amps, 125 Volts D.C., or 10 Amps, 250 Volts A.C. without relays. Liquid-filled sensing element assures minimum heat transfer path, fast response, control within ±2°F. Thousands of variations possible. Temperature ranges: from −75°F to +300°F. Single Type Bulletin MC-120. Dual Type Bulletin MC-143.



MIDGET AND MINIATURE UNITS FOR TIGHT SPOTS

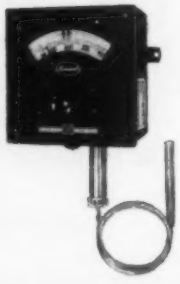
Midget Units. Outside stainless steel shell diameter of ¼" provides high sensitivity and resistance to vibration, assuring accurate control under severest conditions. Temperature range: −50°F to +500°F. Bulletin MC-124.



Miniature Units. Sugar-lump size, with stainless steel shell plus high sensitivity and vibration resistance. Temperature range: −20°F to +275°F. Available in adjustable and hermetically-sealed types. Bulletin MC-124.

NEW TEMPERATURE INDICATING CONTROLLERS

The New Series 541 bulb-and-capillary controllers offer single or dual switch control, choice of four snap-switch types and five temperature ranges: −150°F to +200°F, 50°F to 200°F, 50°F to 300°F, 50°F to 400°F and 50°F to 700°F. Special ranges available on request. Corrosion-proof capillaries and bulbs assure long life and easy operation. Explosion-proof modification available for single switch models. Bulletin MC-176.



Fenwal
INCORPORATED
59 Pleasant St., Ashland, Mass.

For complete information about Fenwal devices, or about modifications for special applications, write us.

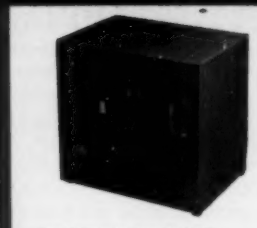
Fenwal Controls Temperature ...Precisely

SPECIALIST SPECIAL TRANSFORMERS

Known for over thirty years for transformer custom-design and manufacture. The illustrations shown here are only a few of the many types manufactured.

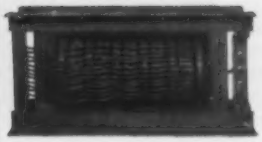
NWL manufactures and designs transformers for—

HEATING
TESTING
POWER
ELECTRONIC
ELECTRIC FURNACE
SPECIAL WELDING
PHASE CHANGING
PRECIPITATION
CONTROLLING
RESEARCH
LIGHTING
INDUSTRIAL
MEASURING
SIGNALING
HIGH AND LOW VOLTAGE



High Voltage Test up to 50 KV. Often equipped with circuit breakers, indicating meter and variable auto transformer input to 20 KVA

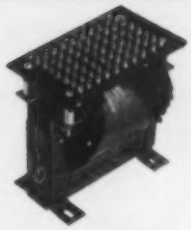
Current Transformer. Phase Angle error corrected 2.4 minutes. Accuracy ½ of 1%. 1 to 10,000 Amperes.



Audio Transformer, from 2 Cycles to 3 KC in sizes from 1 to 100 KVA

Air Core Reactors 0.1 to 50 KVA

Multi-filament transformer up to 10 KVA and up to 60 KV insulation.

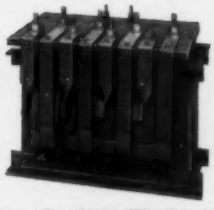


Multi-Voltage Transformer for test or experimental use. 0.1 to 50 KVA

Saturable Core Reactors from sizes 1 to 200 KVA

Rectifying Transformer 1, 2 or 3 Phase, 1 to 3000 Amperes up to 300 KVA

Phase Changing Transformer 2 to 300 KVA



Filament Transformer, 400 cycles with 4 secondaries. 10 volts, 100 Amperes. Each secondary can be mounted in parallel series or series parallel.

Outdoor Potential Transformer, output: 35 KV, 25 KVA continuous duty, Vacuum-oil filled. With brackets for pole mounting.

Heating Transformer for Molybdenum Furnaces: Has a 10,000 Ampere secondary with a maximum of 5 volts. Primary taps extended to reduce secondary to 0.75 volts.

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NEMA

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P.O. Box PEH Trenton, N. J.
Specialists in Custom Building

A quick review of control timer types . . .

INTERVAL TIMERS — for accurate time control where frequent changes in setting are required.

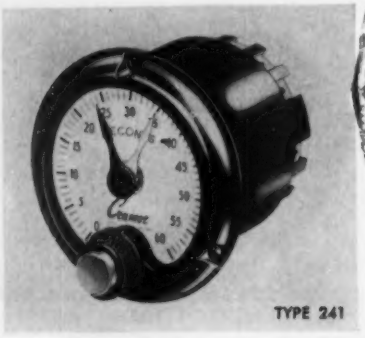
An interval timer consists basically of a constant-speed motor, an arm or cam, and a switch. The user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor. The motor then drives the arm or cam to the set point, where the switch is returned to its original position and the motor shuts off. A variety of dials, knobs, push-button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same in all cases.

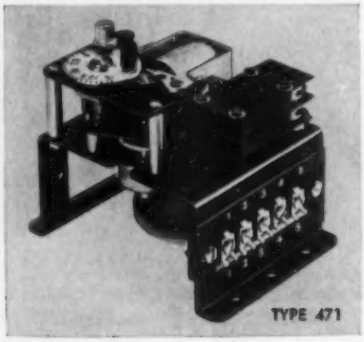
TIME DELAY RELAYS — to introduce an accurate and adjustable delay between the closing of a control circuit and the actuation of one or more independent load switches.

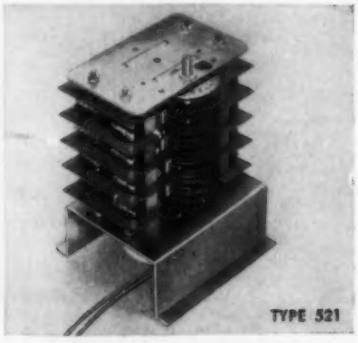
Again, a constant-speed motor drives a set of precision-cut cams from an adjustable starting point to a later point where one or more load switches are transferred. The unit continues to the end of its cycle, at which point the motor shuts off and the timer remains "timed out" until it is reset. Optional automatic reset, various clutching devices, and a wide selection of wiring arrangements make the time delay relay a highly versatile control with countless uses.

CYCLING TIMERS — to control a repeated sequence of operations in a definite time relationship which does not require frequent change.

The basic difference between a cycling timer and a time delay relay is that the cycling timer continues to run, cycle after cycle, until it is shut off. The single-pole double-throw load switches are transferred back and forth, at exactly determined times, by cams fixed to the motor shaft. Multiple load switches, an almost endless number of cam combinations, excellent accuracy, and a wide range of basic cycle speeds make the cycling timer an ideal program-control device in many processes.


TYPE 241


TYPE 471


TYPE 521

. . . you can choose at a glance from this table

CLASS	INTERVAL TIMERS		TIME DELAY RELAYS					CYCLING TIMERS	
CRAMER TYPE	241	271	310	330	440A	412	471	511-21	571
Time Ranges	6 s to 24 h	45 s to 24 h	15 s to 120 s	20 s to 80 s	15 s to 3 h	6 s to 24 h	15 s to 24 h	6 s to 48 h	60 s to 3 h
Load Switches (SPDT)	1	1 or 2	1	1 or 2	1 to 5	1	1 or 2	1 to 8	1 to 4
Automatic Reset	Yes	No	Yes	Yes	Yes	Yes	Yes	—	—
Repeat Accuracy (% of total range)	¼%	½%*	½%	¾%	½%	¼%	2%	½%	1½%
Progress Indication	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Adjustable	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Operated by:									
Momentary contact	No	No	No	No	Yes	Yes	Yes	No	No
Sustained contact	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mounting	Panel	Back Panel	Panel	Surface	Surface	Panel	Surface	Surface	Surface
Unit List Price	$24.00	$ 8.00 or $10.00	$27.00	$18.00 or $23.00	$42.00 to $66.00	$42.00	$23.50 or $27.50	$16.00 to $44.00	$ 8.50 to $11.50
Motor & clutch rating	All standard voltages in 50, 60 and 400 cps AC, and in DC								

**Exclusive of human setting error*

LEARN MORE about these and other basic timing devices from Cramer's complete line. Write for free bulletins on the types that interest you — or describe your problem and let us help you solve it.

CRAMER CONTROLS
CORPORATION
Box 7, Centerbrook, Connecticut

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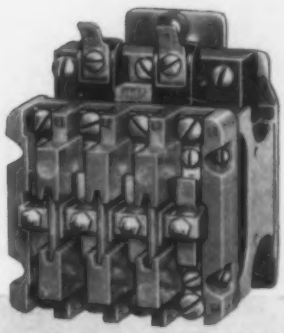
This Complete RBM Control Family

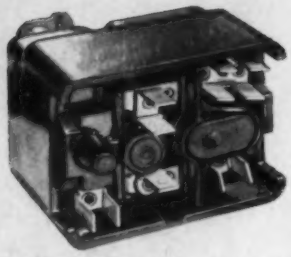
is specially engineered for the air conditioning industry

When RBM specially engineered its first air conditioning control, it quickly recognized the industry need for not just one . . . but for a *complete family*. So RBM has done the job. Now there is a single source for *all* magnetic air conditioning controls . . . each one meticulously engineered for its application. What's *your* requirement? See RBM.

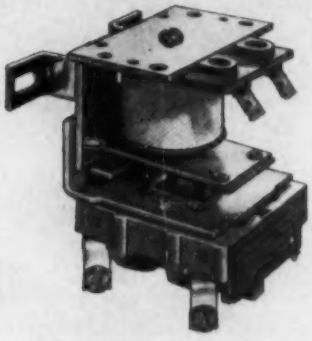


TYPE C—30, 40, 50 AMP. 2-3-4 pole 30 amp.—600 volts. 2-3-4 pole 40 amp.—230 volts. 2 pole 50 amp.—230 volts. Same mounting holes and coils for all ratings and pole forms.

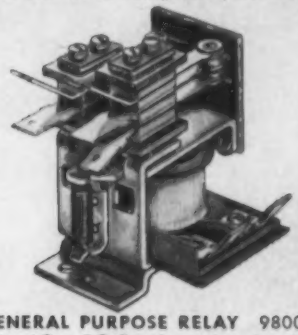
ALL PRICED TO MEET THE NEEDS OF VOLUME USERS



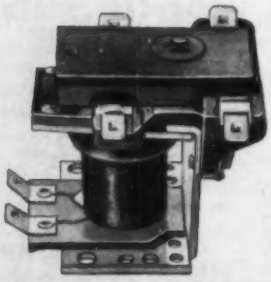
SERIES 128000 POTENTIAL STARTING RELAYS For starting single phase capacitor start compressors.



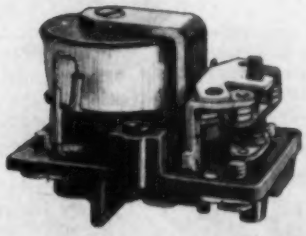
TYPE 80 CONTROLLER Specific design for nominal 3 HP or 3-ton single phase compressors.



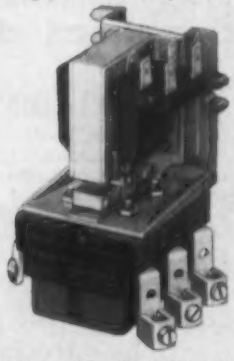
GENERAL PURPOSE RELAY 98000 Series AC or DC. Permits engineering short cuts lowering your "finished product" cost.



TYPE 75 Low cost power relay. Dependably handles up to 6000 W. at 240 V., resistive load per pole. Compressor rating 2 poles, 18 amp. running, 90 amp. locked rotor at 250 volts.



SERIES 129000 SHUNT TYPE RELAY—SPNO, SPNC or NO-NC For standard commercial voltages. Other coils available for special application. For heater, fan control, general circuit switching, etc.



TYPE S—30—40 AMP. Low cost. Small size. Exceed rigid requirements of industry's largest users.

Consult your local RBM Product Application Engineer or Write for Bulletins 1030A, C-8, 1010A, 1060 and C-10.

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Precision switches to meet a wide variety of product design and plant use applications

MICRO SWITCH precision switches are important components in almost every type of electrically operated equipment—from delicate instruments to massive machine tools. They are installed on existing plant equipment to make operation safer, more automatic, and more productive. Shown here are but a few of the many thousands of MICRO SWITCH precision switch types which are famous throughout industry for utmost reliability, long-life, and precise operation.

Look for these features when you buy precision switches

Experience—MICRO SWITCH is a pioneer in the manufacture of precision snap-action switches to meet a wide variety of applications.

Quality—MICRO SWITCH products are laboratory-tested from raw materials to the finished product. Absolute reliability and uniformity of performance is assured.

Service—Experienced MICRO SWITCH Field Engineering Service is available from branch offices in key cities for consultation on switch problems.

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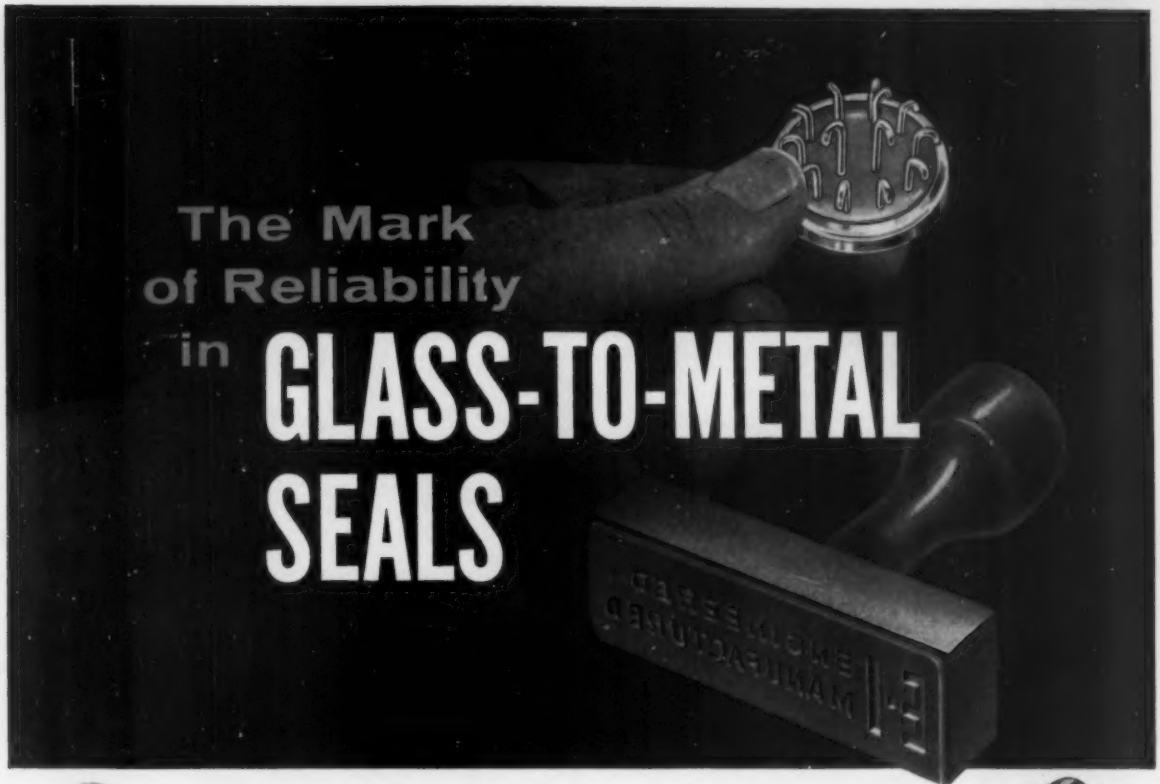

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Compression End Seals

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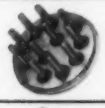
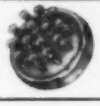

Plug-in Connectors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Consult E-I for Complete Design-Engineering Service on your next Sealing Problem... Sales Engineers Located in all Principal Cities

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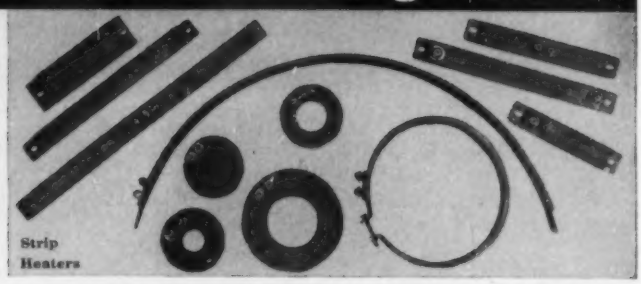
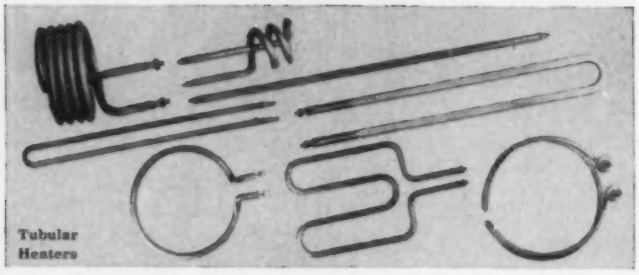
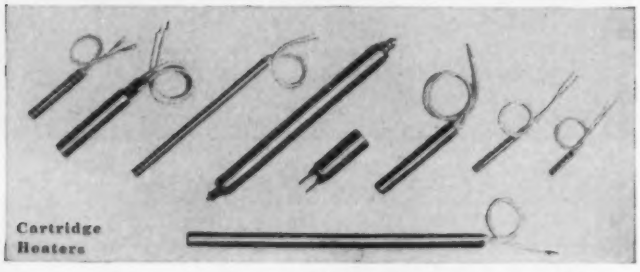
Call your CHROMALOX Man for the heating answers







These 3 basic CHROMALOX heaters provide answers to just about any heating problem

Strip Heaters . . . that quickly and easily bolt or clamp to platens, dies, kettles, tanks, pipes, rolls, drums, ovens and air ducts. Lengths from 4 to 96 inches, widths from ¾ to 2½ inches, with cross section curving or lengthwise bending. Available with brazed-on fins.

Tubular Heaters . . . that clamp on, fit into machined grooves, cast into metals, immerse in liquids, install in ovens and ducts. Straight lengths or factory-formed to nearly any contour. Lengths from 6 inches to 30 feet. Triangular or round cross section. Available with brazed-on fins.

Cartridge Heaters . . . that smoothly fit standard drilled holes in dies, platens, molds, extrusion and injection barrels. Special leads available for protection against flexing action, abrasion, moisture or vapors. Diameters from ⅜ to 1¹⁹⁄₆₄ inches, lengths from 1⅛ to 25⅜ inches.

Versatile Chromalox electric heaters are available in sheath materials and wattages to match almost any application to 1100°F. Easy to install, they are fast, clean, safe and economical.

Your Chromalox Man can help you determine the one that best answers your specific problem. He's backed by the world's largest factory stock of industrial heaters, ready for immediate shipment. Why not give him a call. You'll find his phone number listed at the right.

Our new Catalog 60 provides detailed product information and suggests numerous applications for the complete line of Chromalox electric heaters for industry. If you have not yet received a copy, please let us know.

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New catalogs offer design engineers important reference tools

MASTER CATALOG 57-S

More than a catalog, this complete volume supplies comprehensive design engineering data on automatic transfer switches, remote control switches, contactors, relays, solenoids, and electric plant control.

For the engineering specialist who is concerned with components of the ASCO electromagnetic control line, individual catalogs are available covering:

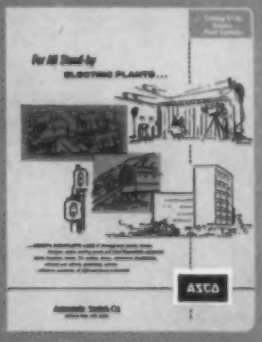
57-S1 AUTOMATIC TRANSFER SWITCHES
. . . designed to transfer a load automatically from a normal source to an emergency source upon failure or reduction in voltage of normal source. For all classes of load, mechanically or magnetically held.

57-S2 REMOTE CONTROL SWITCHES
. . . for convenient and accessible control of power and lighting circuits from any number of control stations. For all classes of load, mechanically held.

57-S3 CONTACTORS
. . . designed to allow unlimited combinations, including multi-pole, special contact arrangements and materials, and other "engineered to fit" features. For all classes of load, normally open and normally closed, magnetically held.

57-S4 RELAYS
. . . magnetically and mechanically held in unlimited pole combinations – plus a highly diversified line of special purpose relays listed as standard catalog items.

57-S5 SOLENOIDS
. . . A-C and D-C, catalog listed or engineered to your requirements.



57-S6 ELECTRIC PLANT CONTROLS
. . . complete systems and components, paralleling, changeover, and alternating panels, load-demand controls, battery chargers and adapter units.

Additional technical literature . . .

Also available is the ASCO engineering study, "Factors to Consider in the Selection of Automatic Transfer Switches."

Catalog 201 on ASCO Solenoid Valves covers more than 1300 types – 2-, 3-, and 4-way with standard, explosion-proof or watertight enclosures–in a wide range of body materials.

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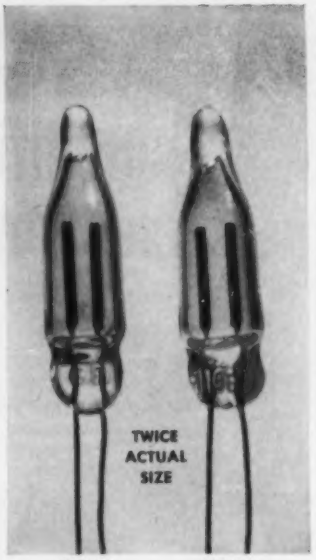
Two G-E Glow Lamps that give you a choice of

CRITICAL OPERATING VOLTAGES

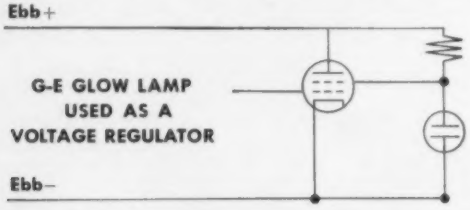


NE-68 NE-80

Here are two pre-tested and stable components engineered by G.E. for your circuit requirements

G-E NE-68—This pre-aged glow lamp has an operating voltage range of from 52 to 65 volts d-c. Its leads are plated to insure easier soldering and its performance in darkened areas is improved by a mildly radioactive additive. The lamps are also treated by the G-E Dri-film process for high leakage resistance under humid conditions. Polarity is indicated by a *blue* dot adjacent to the anode lead.

G-E NE-80—(Similar to the G-E NE-68)—Pre-aged, stabilized glow lamp with a narrower operating voltage tolerance than the NE-68 (range: 50-58 volts d-c). This glow lamp offers uniform operation within predetermined limits. It employs a mildly radioactive additive and has been treated by the G-E Dri-film process, providing a leakage resistance of 100 megohms or greater under humid conditions. G-E NE-80 serves well in circuitry requiring a close tolerance on operating voltage, such as voltage regulators and voltage references. Polarity is indicated by a *yellow* dot next to the anode lead.



DIRECT CURRENT CHARACTERISTICS

	NE-68	NE-80
Starting Volts	60-90-volts d-c	(Max.) 80-volts d-c
Operating Volts	52-65-volts d-c	50-58-volts d-c
Extinction Volts (in series with .25 megohm or more)	50-volts d-c	50-volts d-c
Design Current	0.3 m.a.	0.1 m.a.
Leakage Resistance (at high humidity)	100 megohms	100 megohms

NE-68 Life Change in *operating volts* at 0.3 m.a. is 5-volts in 6,000 hours

NE-80 Life *Operating Voltage* to stay within above limits for 2,000 hours when operated at 0.1 m.a.
Starting Voltage—Not more than 5-volts change from initial, in 2,000 hours at 0.1 m.a.

Choose the General Electric Glow Lamp best for your circuit application. For further information, write for "Glow Lamps as Circuit Control Components". General Electric Co., Miniature Lamp Dept. M-902, Nela Park, Cleveland 12, Ohio.

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(I-62) Plugs and Receptacles—Bulletin, 8 pp. Gives data on single conductor plugs and receptacles, grip design and color range, 50 and 100 amp. The Superior Electric Co, 83 Laurel St, Bristol, Conn.

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(I-66) Lighted Display and Pushbutton Switch Devices—Catalog, 20 pp. Description of modular indicator and pushbutton units, mounting data, electrical ratings, prices and color coding. Micro Switch, A Division of Minneapolis-Honeywell Regulator Co, 11 W Spring Street, Freeport, Ill.

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(I-69) Switches and Relays—Catalog, 64 pp. Data sheets, price and discount schedules of various snap action switches. Acro Div, Robertshaw-Fulton Controls Co, 2040 E Main St, Columbus, Ohio.

(I-70) Electrical Enclosures—Catalog, 16 pp. Electrical enclosures and wireway to JIC and NEMA standards, oil and dust tight. Includes dimensions, standard sizes and detailed drawings. Hoffman Engineering Corp, 9th & Tyler, Anoka, Minn.

(I-71) Permanent Magnets—Catalog, 12 pp. Describes cast and sintered permanent magnets, sizes and ordering information. Also, includes magnetizers. The Indiana Steel Products Co, 405 Elm Street, Valparaiso, Ind.

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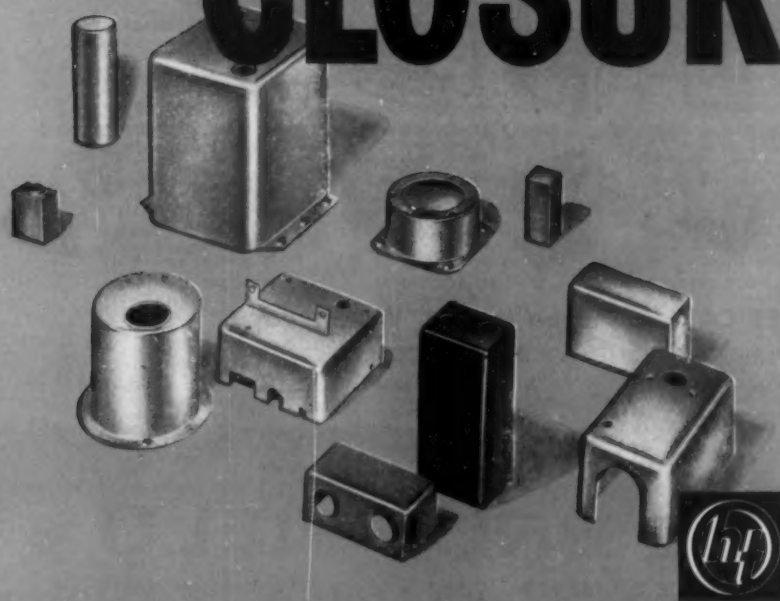
Hudson facilities range from batteries of standard and special presses to a fully equipped sheet metal department capable of handling your most rigid requirements.



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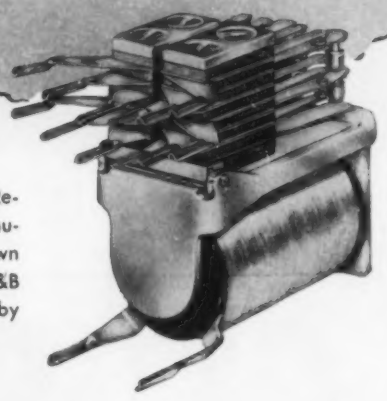

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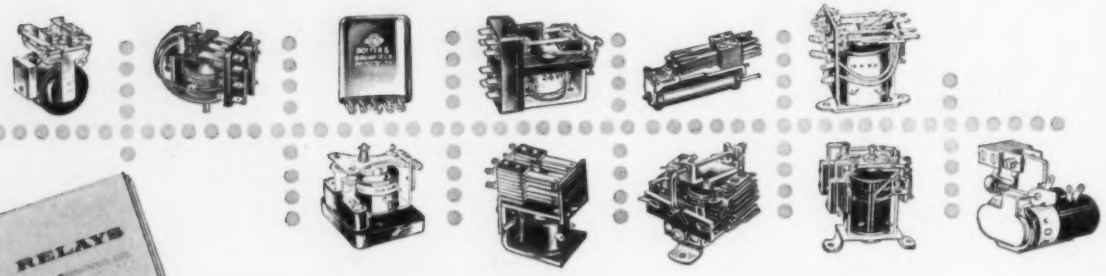

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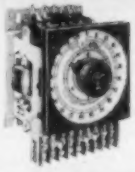
FOR INDUSTRIAL PROCESSES



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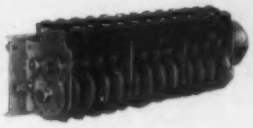
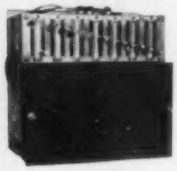
A 20 turn dial for maximum accuracy. Choice of 10 time ranges from .01 sec. to 100 hours. Three SPST 15 amp contacts.



BUL. 340
CAM TIMER
With 1 to 12 switches in standard frame sizes. Has gear change feature and adjustable cams.



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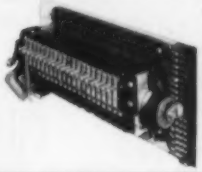
MULTIPLE CIRCUIT TIMER
Each circuit has separate ON-OFF adjustments — ideal for sequence timing.

BUL. 720
COUNT SWITCH
Trips switch after preadjusted count. With 400 count dial. Automatic reset. Electric and mechanical drives available.

BUL. 165
TIME DELAY RELAYS
Adjustable delays up to 3 minutes provided by this relay with 20 amp SPDT switch.



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STEP SWITCH
Heavy duty Step Switch sequence 1 to 19 circuits actuated by break out cams. Operates from pulses, operates on AC. 10 amp contacts.

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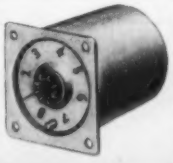
ADJUSTABLE REPEAT TIMER
Extra large 6" dial with separate ON-OFF settings. Ideal for jobs requiring widely different timing.



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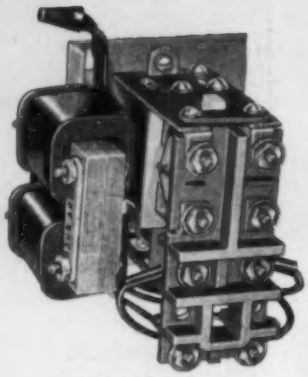
Floatless, Electrode Type, Liquid Level Controls



2 Pole Level Control

TYPICAL APPLICATIONS

- Pump Controls
- High and Low Level Cutoffs
- High and Low Level Alarms
- Multi-level Signals
- Volumetric Metering
- Boiler Feedwater and Cutoff
- Sewage Ejector Controls
- Carbonator Pump Controls
- Submersible Pump Cutoff
- Evaporator Cutoff
- Process Industries Controls
- Special Panels and Controls

PRINCIPLE OF OPERATION—The operation of controlling liquid levels by means of electrodes is simple, accurate, and positive. A combination of a matched relay and transformer, integrally mounted on a common baseplate and connected to one or more electrodes positioned to contact the liquid surface at predetermined levels, actuates the opening and closing of electrical contacts on the relay. The contacts may be used to switch a motor, motor starter, contactor, motorized valve, solenoid valve, alarm bell, pilot light or any other device.

SALIENT FEATURES—There are no moving parts in the liquid. Installation is easy, requiring no adjustment aside from cutting the electrodes to their proper lengths. Operation is unaffected by acids, alkalis or caustics and is independent og temperature and pressure. The control can be located remote from the liquid container. Levels can be maintained within 1/16 inch. All terminals are located on a single panel on top of the relay for accessibility. All contacts and moving parts are situated below the main panel for maximum protection. Spacing and insulation are adequate for 600 volts. The baseplate is provided with keyhole for mounting screws. Equipment is listed by Underwriters Laboratories.

ELECTRICAL RATINGS—Controls are available with coils suitable for any combination of supply line voltage and frequency. Contacts are U/L rated at 1 HP for 115 or 230 volts, 10 amperes 115 volts or 5 amperes 230 volts inductive load, and 690 volt-amperes 230 volts or 125 volt-amperes 460 volts for pilot duty. All controls are of the double break, bridge type and have wiping action on closure.

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THAT WILL WITHSTAND 2000°F AND UP TO 50,000 PSI

LONG LIFE

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Thermocouple Lengths to 50 feet
Complete Thermocouples made to every requirement.

NEW, SIMPLE CONSTRUCTION

A metallic sheath compressed over ceramic insulated wire. Sheath can be bent and weldments can be performed without loss of insulation.

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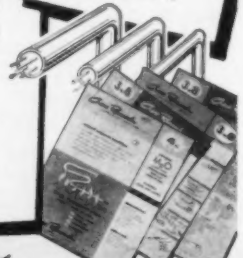

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catalogs and bulletins.....continued

(I-72) Static Converters—Bulletin, 4 pp. Gives output, voltage regulation, construction and circuit operation of 30, 60, 100 and 200 watt regulated and unregulated, dc-dc static converters. Magnetic Amplifiers, Inc, 632 Tinton Ave, NY 55, NY.

(I-73) Sub-miniature Relays—Brochure, 4 pp. Description of basic design intended to meet extremes of various specifications. Typical ratings, mountings, terminal patterns, dimensions, and other technical data. Leach Corp—Relay Division, 5915 Avalon Blvd, Los Angeles 3, Calif.

(I-74) Wire-wound Resistors—Catalog, 12 pp. Contains dimensions and values of vitreous enamel wire-wound resistors, 3 to 200 watt sizes. Ward Leonard Electric Co, Mount Vernon, NY.

(I-75) Automatic Controls—Catalog, 48 pp. Describes individual controls for heating, air conditioning and refrigeration; gives engineering specifications, features and types available. White-Rodgers Co, 1209 Cass Ave, St Louis 6, Mo.

(I-76) Terminal Boards—Bulletin, 4 pp. Gives dimensions, hardware, electrical values and describes design features of solid back molded terminal board. General Products Corp, Salem St, Union Springs, NY.

(I-77) Centrifugal Switches—Bulletin, 6 pp. Describes various types, principles of operation, applications and features of overspeed limiting devices for engines. Torq Engineered Products, Inc, Bedford, Ohio.

(I-78) Extension Cable—Catalog, 4 pp. Describes types of polyvinyl-insulated, multi-conductor cable for installing numerous leads at same time. Thermo Electric Co, Inc, Saddle Brook, NJ.

(I-79) Integral Lighting Systems—Catalog, 34 pp. Various methods of lighting and description of materials and finishes that can be used. Information on applications for aircraft instruments. Ackerman Engravers, 458 Broadway, NY 13, NY.

(I-80) Electronic Tube Parts—Catalog, 12 pp. Describes facilities, construction, materials and types of tubebases, caps and lead wires. The Engineering Co, 27 Wright St, Newark, NJ.

(I-81) Amplifiers—Bulletin, 2 pp. Shows electrical characteristics, applications, and capacities of instruments for dc measurement. Minneapolis-Honeywell Regulator Co, Boston Div, 40 Life St, Boston 35, Mass.

(I-82) Tube Shields and Retainers—Brochure, 6 pp. Describes materials, construction features, basic styles, dimensions and applications. The Staver Co, 41 N Saxon Ave, Bay Shore, NY.

(I-83) Ac and Dc Miniature Relays—Bulletin, 16 pp. Describes construction, applications, military specifications, ratings, mounting arrangements and ordering procedure. Union Switch & Signal—Div of Westinghouse Air Brake Co, Braddock Avenue, Pittsburgh 18, Pa.

The **NEW *Series* BH100**

MILLI-V-METER*

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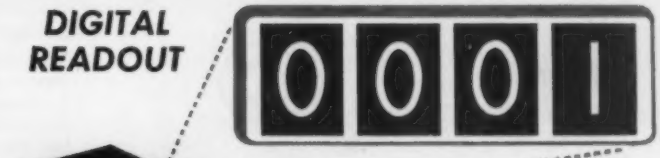

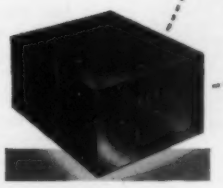

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ACCURACY 0.1%

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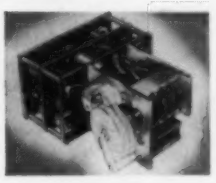
for* FLOW · PRESSURE LEVEL · TEMPERATURE *etc.



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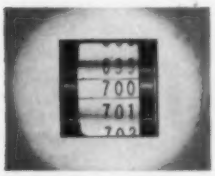

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Statham products offer the instrumentation engineer the following benefits: Infinite resolution — Highly linear output — Minimum hysteresis — Excellent repeatability — Low response to extraneous vibration and acceleration — Unprecedented reliability and operating life — The convenience of electrical calibration and checkout.

MODEL A5
linear accelerometer

RANGE: ±2 to ±1,000 g
The model A5 accelerometer is versatile, easy to mount, and designed for applications in which high frequency response is important. Requiring an excitation of 9-12 volts, DC or AC, this model has an output of from ±35 to ±55 millivolts. This is a ruggedly constructed instrument. Weight: 4 oz., approx.

MODEL PA208
miniature absolute pressure transducer

RANGE: 0-5 to 0-1,000 psia
This flush diaphragm unit can be converted into a chamber-type pressure transducer, if required, with the use of interchangeable adapters, offered in the Statham catalog. This unit is well suited for applications where high frequency response is required. Its combined non-linearity and hysteresis error is guaranteed to be less than 0.75% of full scale. Weight: ½ oz., approx.

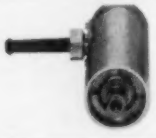
MODEL PG10
gage pressure transducer

RANGE: 0-50 to 0-10,000 psig
Designed to offer a large selection of ranges with excellent over-range protection, this model pressure transducer may be used, for example, in the measurement of surge pressures in airborne hydraulic systems. This model is used for the measurement of gage pressures. Weight: 17 oz. approx.

MODEL PM80
bi-directional differential pressure transducer

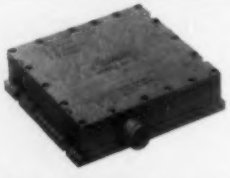
RANGE: 1.0 to 5,000 psid
The unique construction of this pressure transducer permits the introduction of corrosive liquids to both the reference and the positive pressure ports. This model is available in wide ranges, and maximum line pressures of 9,000 psig can be applied. Over-range protection in both directions is provided. Weight: 12 lbs., approx.

MODEL LB2
load cell



RANGE: ±10 to ±25 lbs. tension-compression
The overload limits of this high quality instrument are 2 times the range in compression and 1.1 times the range in tension. This model may be operated within ambient temperature limits of −65° to +250°F. Weight: 1 lb., approx.

MODEL CA3
strain gage signal amplifier



OUTPUT: 0-5 volts DC
The Statham strain gage signal amplifier provides amplification to voltage levels suitable for direct use in telemetery. The 0-5 volts DC output is proportional to the transducer output. This unit provides excitation for the transducer. Potentiometers are included to allow zero and sensitivity adjustment. Weight: 14.5 oz., approx.

For further information on these instruments, or other Statham products, please write to the sales engineer in your area, or Statham, Dept. PED-624-1

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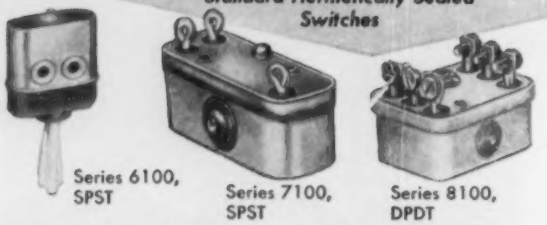


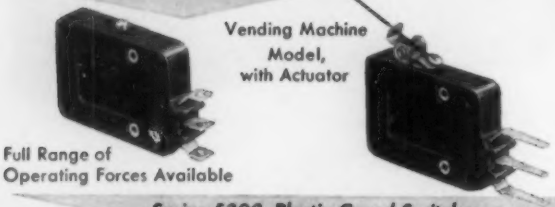
Series 6100, SPST

Series 7100, SPST

Series 8100, DPDT

These switches meet requirements of MIL-S-6743 and MIL-E- 5272A, Procedure II (vibration).

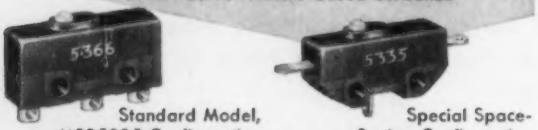
Series 5200 Plastic Cased Switches



Vending Machine Model, with Actuator

Full Range of Operating Forces Available

Series 5300 Plastic Cased Switches

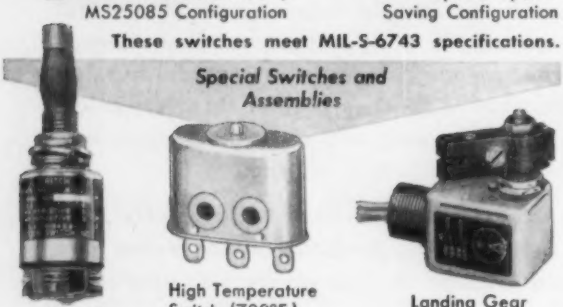


Standard Model, MS25085 Configuration

Special Space-Saving Configuration

These switches meet MIL-S-6743 specifications.

Special Switches and Assemblies



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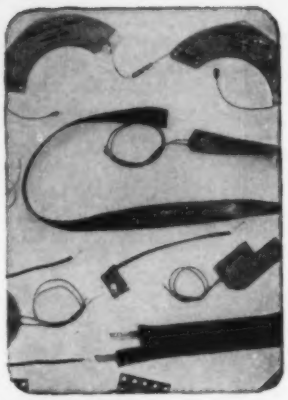

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catalogs and bulletins.....continued

(I-84) Electrical Switches—Brochure, 2 pp. Describes construction and operation; offers technical information and ordering data. Pass and Seymour, Inc, Syracuse 9, NY.

(I-85) Electrical Components—Catalog, 13 pp. Gives curves, outline drawings, engineering and ordering information for solenoids, transformers, coils and others. Anderson Controls, Inc, 9959 Pacific Ave, Franklin Park, Ill.

(I-86) Molded Products and Components—Catalog, 11 pp. Gives materials, dimensions, ratings and diagrams for insulated terminals, coil forms, connectors and others. Garde Manufacturing Co, 53 John St, Cumberland, RI.

(I-87) Electronic Components—Catalog, 6 pp. Describes various rectifiers and regulators; mechanical and electrical specifications, ratings and graphs. North American Electronics, Inc, 212 Broad St, Lynn, Mass.

(I-88) Terminal Blocks—Catalog, 12 pp. Gives engineering, ordering and pricing information, selection charts, diagrams and specifications. Curtis Development & Mfg Co, 3266 North 33rd St, Milwaukee, Wisc.

(I-89) Adjustable Power Supply—Bulletin, 4 pp. Suggested uses, ratings and specifications given for power supply, either ac or dc applications. The Superior Electric Co, 83 Laurel St, Bristol, Connecticut.

(I-90) Transistorized Amplifier—Bulletin, 9 pp. Gives electrical characteristics, mechanical specifications and applications of various models. Also, photographs and performance data. Gulton Industries, Inc, 212 Durham Ave, Metuchen, NJ.

(I-91) Electrical Switches—Catalog, 32 pp. Glossary of electrical terms pertaining to switches, specifications and dimensional data, ratings and photographs. Licon Division, Illinois Tool Works, 6606 W Dahin St, Chicago, Ill.

(I-92) Solenoid Contactors—Brochure, 12 pp. Photos and description of aircraft quality contactors with various contact arrangements, dimenisons, schematics and mountings for 25, 50, 100, 200 and 400 ampere at 28 v dc. Leach Corp, Relay Div, 5915 Avalon Blvd, Los Angeles 3, Calif.

(I-93) Semiconductor Devices—Catalog, 25 pp. Contains price lists, transistor and replacement charts, data sheets on germanium transistors, silicon rectifiers and transistor circuits. Semiconductor Products, Bendix Aviation Corp, Red Bank Div, 201 Westwood Ave, Long Branch, NJ.

(I-94) Transistors and Diodes—Bulletin, 16 pp. Contains data on specifications for different types of transistors and diodes along with outline drawings and dimensions. Clevite Transistor Products Div, Clevite Corp, 241-257 Crescent St, Waltham 54, Mass.

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BRUSH HOLDER ASSEMBLIES
BRUSH CONTACTS
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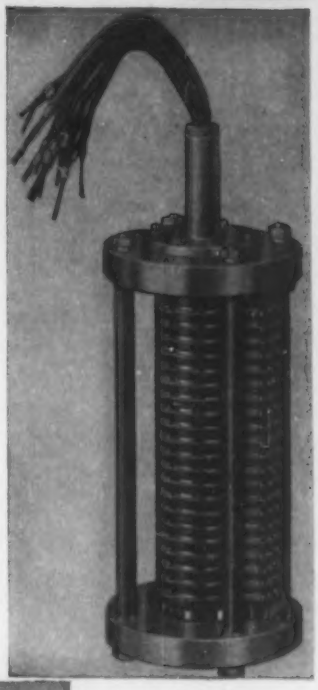

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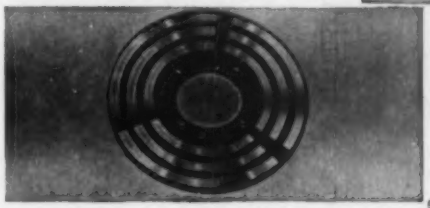
SPECIAL BRUSH BLOCKS
COMBINATION SIGNAL AND POWER CIRCUITS



↑ *Basic drum-type assembly with 24 rings.*
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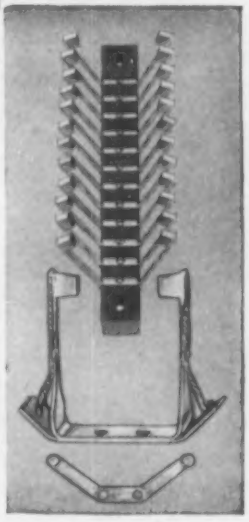

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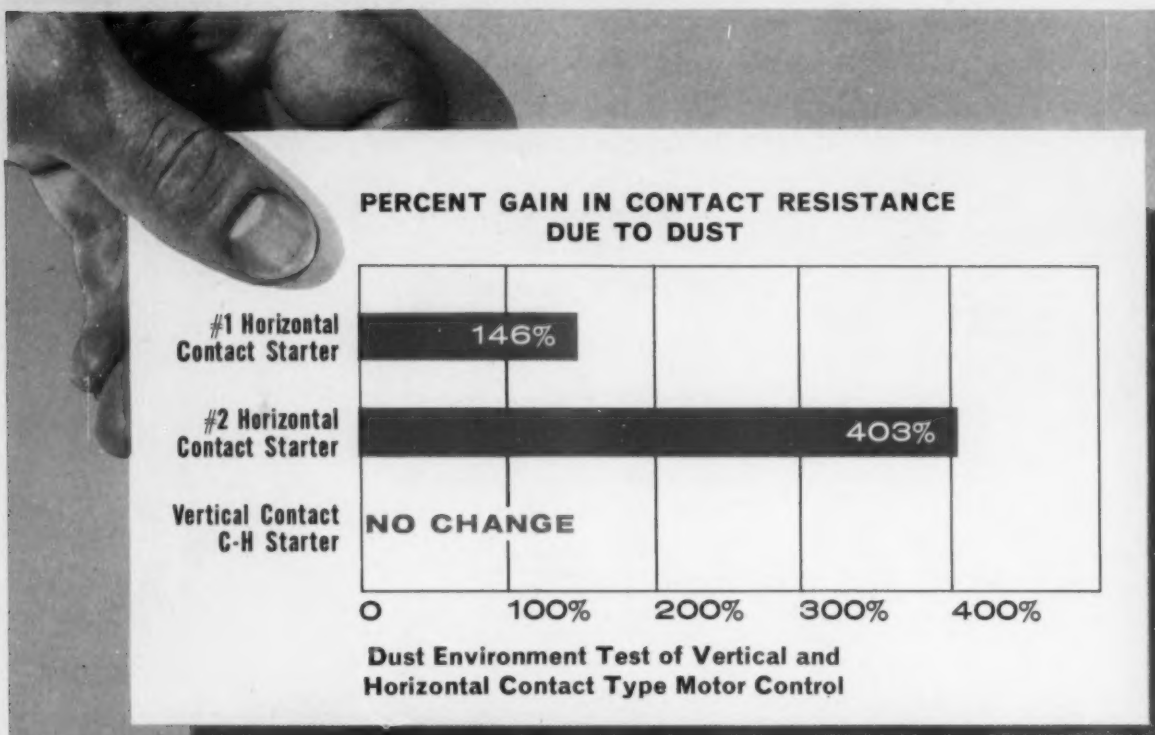

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"Dust can't collect on a vertical surface." This is a simple fact, but an important one to users of motor control. To function properly the contacts in motor control *must* stay clean, free from all forms of dust under all operating conditions. And because dust can't collect on a vertical surface, only vertical contacts are truly *dust-safe*. For proof look at the results of this test.

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catalogs and bulletins.....continued

(I-95) Miniature Circuit Breaker—Bulletin, 2 pp. Low amperage overcurrent circuit breaker rated from 50 milliamp to 25 amp, 24 v dc, 240 v ac. E-T-A Products Co of America, 6284 N Cicero Ave, Chicago 46, Ill.

(I-96) Insulators—Bulletin, 4 pp. Physical and electrical properties, specifications, prices and advantages of fiber glass reinforced polyester materials. Uses 2¼ in. corrugated types for bus, contactor and switch support work. The Glastic Corp, 4321 Glenridge Rd, Cleveland 21, Ohio.

(I-97) High-speed Circuit Breakers—Bulletin, 6 pp. Contains descriptive and technical information about high speed, current-limiting dc circuit breakers. Principal applications of these breakers are for generators, motors, anode protection and as feeder breakers. Wiring diagrams and outline drawings are included. I-T-E Circuit Breaker Co, 1900 Hamilton St, Phila 30, Pa.

(I-98) Relays—Brochure, 16 pp. Describes plant facilities, basics of balanced armature design, typical ratings, dimensions and electrical data. Leach Corp, Relay Div, 5915 Avalon Blvd, Los Angeles 3, Calif.

(I-99) Telemetering System—Brochure, 16 pp. Gives physical and operational characteristics of systems and specifications of its components. Stavid Engineering, Inc, US Highway 22, Plainfield, NJ.

(I-100) Connectors, Terminals and Blocks—Catalog, 16 pp. Dimensions, specifications and ordering information for sectional and unit terminal blocks, solderless splicing and terminating fittings, installation tools and other electrical equipment. Buchanan Electrical Products Corp, Hillside, NJ.

(I-101) Variable Transformers—Bulletin, 8 pp. Describes line of small variable transformers featuring increased ratings. Dual ratings and specifications given. The Superior Electric Co, 83 Laurel St, Bristol, Conn.

(I-102) Nickel-cadium Batteries—Bulletin, 8 pp. Power units for unattended maintenance providing source of dc power. Includes typical cell discharge curves, sizes, voltage ratings, electrical and mechanical specifications. Gulton Industries, Inc, 212 Durham Ave, Metuchen, NJ.

(I-103) Electrical Contacts and Assemblies—Catalog, 15 pp. Describes alloy and powdered metal contact materials, forms and assemblies; typical applications, properties tables and engineering services are given. Gibson Electric Co, Box 634, Delmont, Pa.

(I-104) Electronic Equipment—Catalog, 26 pp. Describes various proximity pickups, control units, magnetic pickups and transistorized tachometers. Gives specifications, prices and types of application. Also includes illustrations and selection aids. Electro Products Laboratories, Inc, 4501 N Ravenswood Ave, Chicago 40, Ill.

(I-105) Commutators and Slip Rings—Brochure, 20 pp. Gives specifications, testing standards and assembly methods for commutators and slip rings. Also contains photographs of products and facilities. The Nippert Electric Products Co, 1759 W Mound St, Columbus, Ohio.

(I-106) Power Supplies—Bulletin, 8 pp. Gives construction details, standard performance specifications for stationary indoor models under and over 40 kw, mobile equipment and custom designs. Leach Corp, Inet Div, 18435 Susana Rd, Compton, Calif.

(I-107) Electronic Components—Catalog, 72 pp. Gives dimensions, color coding, ratings and photographs of connectors, cables, antennas, and others. Amphenol-Borg Electronic Corp, Amphenol Sales Div, 2801 S 25th Ave, Broadview, Ill.

(I-108) Connecting Leads—Bulletin, 2 pp. Specifications on multiple connection patch cords for interconnecting electronic test equipment. Gives prices and ordering information. Associated Engineering Corp, 65 Kent St, Brookline 46, Mass.

(I-109) Wire and Cable—Bulletin, 6 pp. Shows products manufactured, facilities, military and commercial electronic applications. Chester Cable Corp, Subsidiary of Miami Copper Co, Chester, NY.

(I-110) Power Supply Cords—Catalog, 24 pp. Drawings and descriptions of stock molds for male caps, female connectors, strain reliefs, and others. Illustrations of representative types of cords. Royal Electric Corp, 95 Grand Ave, Pawtucket, RI.

(I-111)) Batteries—Brochure, 6 pp. Describes battery assembly, chemical reaction, life, charging power capabilities; lists applications and table of typical electrical characteristics. Yardney Electric Corp, 40-50 Leonard St, NY 13, NY.

(I-112) Automatic Voltage Regulators—Bulletin, 8 pp. Describes transistorized line for ¼, ½, and 1 kva duty. Gives ratings and characteristics. The Superior Electric Co, 83 Laurel St, Bristol, Conn.

(I-113) Capacitors—Catalog, 13 pp. Layer wound capacitors, high voltage power supplies, radio noise filters and electronic devices are described. The Potter Co, 1950 Sheridan Rd, North Chicago, Ill.

(I-114) Dc Power Supplies—Bulletin, 4 pp. Describes method of operation, electrical performance data and additional design features. Leach Corp, Inet Division, 18435 Susana Rd, Compton, Calif.

(I-115) Control Transformers—Bulletin, 4 pp. Describes the high inrush capacity of the transformer. Tables of specifications and charts to aid in the selection of the proper kva ratings are included. Hevi-Duty Electric Co, 2040 W Wisconsin Ave, Milwaukee, Wisconsin.

(I-116) Limit Switches—Bulletin, 6 pp. Contains description, features, dimensional data, specifications, prices and ordering information. R B Denison Mfg Co, 102 St Clair Ave, Cleveland, Ohio.

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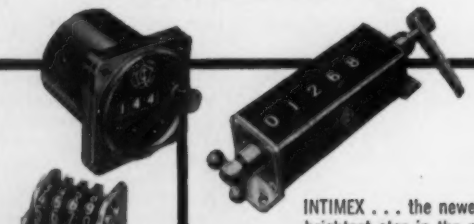

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catalogs and bulletins.....continued

(I-117) **Coaxial Switches and Relays**—Catalog, 26 pp. Pertinent electrical and dimensional information on coaxial switches, relays, waveguides and coaxial block components. Industrial Products-Danbury Knudsen Div, Amphenol-Borg Electronics Corp, 79 E Franklin St, Danbury, Conn.

(I-118) **Electrical Brushes**—Catalog, 12 pp. Describes brush design and materials along with selection factors and application information. Speer Carbon Co, St Marys, Pa.

(I-119) **Wiring Diagram for Starting Switches**—Bulletin, 50 pp. Shows the various applications of manual and magnetic across-the-line starters. Wiring and line diagrams, selection and system features. Allen-Bradley Co, Milwaukee, Wis.

(I-120) **Relays**—Bulletin, 4 pp. Describes basic units, variations available in contact structure, and voltages. Aemco Inc, 10 State St, Mankato, Minn.

(I-121) **Limit Switches**—Brochure, 4 pp. Describes construction and applications with special emphasis on contact mechanism; gives engineering data and electrical ratings. Cutler-Hammer, Inc, 296 N 12th St, Milwaukee, Wisc.

(I-122) **Transistor Clips**—Bulletin, 8 pp. Includes drawings of typical retainer designs and discussion of heat dissipating characteristics. Also, selection charts. H Braun Tool & Instrument Co, Inc, 140 Fifth Ave, Hawthorne, NJ.

(I-123) **Industrial Tubes**—Catalog, 30 pp. Listing of features and specifications for vacuum switches, pentodes, rectifiers, and others. Tung-Sol Electric Inc, 95 Eighth Ave, Newark, NJ.

(I-124) **Thermal and Waterproof Switches**—Brochure, 4 pp. Hermetically sealed stainless switches designed for ordinance use. Gives materials, weights, ratings and capabilities. Control Products, Inc, 306 Sussex St, Harrison, NJ.

(I-125) **Terminal Boards and Blocks**—Bulletin, 12 pp. Gives dimensions, materials, specifications and mounting instructions. Kulka Electric Corp, 633-643 S Fulton Ave, Mount Vernon, NY.

(I-126) **Relays**—Catalog, 20 pp. Includes information on design, engineering and performance of standard telephone type, general purpose, power and microminiature rotary relays. Magnecraft Electric Co, 3352 W Grand Ave, Chicago 51, Ill.

(I-127) **Mercury Displacement Relays**—Catalog, 16 pp. Contains description of time delay as well as load mercury relays: ratings, ordering information and mounting dimensions. The Adams & Westlake Co, 1169 N Michigan, Elkhart, Ind.

(I-128) **Permanent Magnets**—Catalog, 16 pp. Stock list showing standard alnico permanent magnets with their physical and magnetic properties. Crucible Steel Co of America, PO Box 2518, Pittsburgh 30, Pa.

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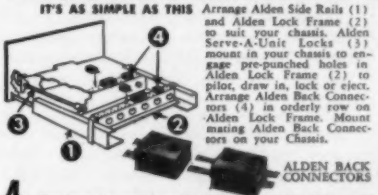

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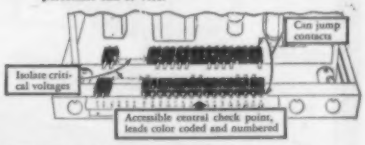

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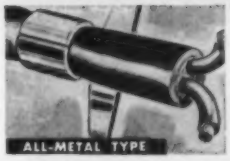

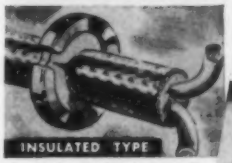

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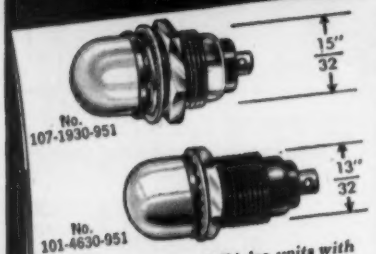

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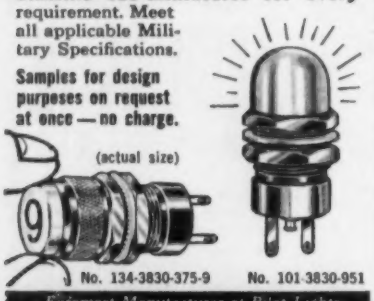

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catalogs and bulletins.....continued

(I-129) Flexible Conduit—Catalog, 8 pp. Gives prices, construction features, weights, diameters and suggested uses for 100 foot lengths of various types. Universal Metal Hose Co, 2133 S Kedzie Ave, Chicago 23, Ill.

(I-130) Electrical Components—Catalog, 20 pp. Describes special straps, shunts, leads, carbon brushes and commutator stones. The Sittler Corp, 18 N Ada St, Chicago, Ill.

(I-131) Electric Heaters—Catalog, 45 pp. Covers cartridge, strip, cylindrical immersion and tubular heaters. Includes list price, wattage charts, circuit diagrams and installation methods. Watlow Electric Mfg Co, 1376 Ferguson Ave, St Louis, Mo.

(I-132) Pilot Lights—Catalog, 8 pp. Applications, construction, specifications, and ordering information for various combinations. Industrial Devices Inc, Edgewater, NJ.

(I-133) Capacitors—Catalog, 16 pp. Lists ratings and technical information for paper, mylar, metallized paper, electrolytic tantalum capacitors. Astron Corp, 255 Grant Ave, E Newark, NJ.

(I-134) Contact Strips and Rings—Bulletin, 8 pp. Contains data on heat treatment, facilities, and bonding process involving beryllium copper parts. Includes tables and dimensional drawings of various contact strips and rings. H Braun Tool & Instrument Co, Inc, 140 Fifth St, Hawthorne, NJ.

(I-135) Resistance Alloys—Bulletin, 4 pp. Contains ohms per foot table, physical properties, standard resistance tolerances and spooling specifications. Available in wire and ribbon form, bare and insulated. The C O Jelliff Mfg Corp, Pequot Rd, Southport, Conn.

(I-136) Germanium Transistors—Brochure, 10 pp. Contains specifications, output and current transfer curves, conversion chart, standard transistor symbols and nomenclature. Includes mounting instructions. Tung-Sol Electric Inc, Semiconductor Div, 95 Eighth Ave, Newark 4, NJ.

(I-137) Electronic Packaging System—Catalog, 12 pp. Describes components and system for layout and packaging of electronic equipment; gives prices and ordering information. Alden Products Co, 111 N Main St, Brockton, Mass.

(I-138) Clips and Insulators—Catalog, 8 pp. Describes and illustrates line of miniaturized and ground clamps. Dimensions, characteristics and applications of alligator, test and battery clips. Mueller Electric Co, 1583 E 31st St, Cleveland, Ohio.

(I-139) Voltage-regulated Power Supplies—Catalog, 16 pp. Gives engineering specification and ordering information for standard model power supplies grouped according to design type, percentage regulation and stability. Kepco Inc, 131-38 Sanford Ave, Flushing 55, NY.

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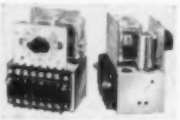
CK Timers use Type 5823 cold-cathode tube that provides instant starting with no tube warmup, immediate recycling, and long tube life. Eight-ampere contacts on all models.

Economy Models A, B, C, D are furnished with choice of six time ranges,—full-scale range of 0.2, 0.5, 1.5, 3, 6, 12, or 24 seconds. Small size—4¾" × 3⅜" × 2".

Model 3 Repeat-cycle Timer has independent adjustment of ON and OFF cycles, plug-in relays; is totally enclosed. Size 5"×4¼"×3¼".

Model 120 General Purpose Timer features plastic-enclosed plug-in relays, seven basic modes of operation, including repeat-cycle timing. Size—4⅞" × 3⅞" × 3½".



Model 2 Voltage-regulated Timer—Timed interval varies less than 2% of full scale for line voltage change between 95 and 125 volts.

SYNCHRONOUS CONTACTORS

Rotating camshaft actuates distributor-type switches to control punch presses, computors, and machine tools; provides protection for looms, punch and die tools. Single- and double-circuit models available. Descriptive bulletin on request.

RELAY, ELECTRONIC

Operated by high-speed low energy impulses

The Type CK electronic relay picks up impulses too small to operate a mechanical relay directly and holds the circuit closed long enough to actuate heavy equipment. Size: 3⅜" × 4⅞" × 3".

FARMER ELECTRIC
Products Company, Incorporated
2300 WASHINGTON ST. NEWTON LOWER FALLS, MASS.

catalogs and bulletins.....continued

(I-140) Hermetically Sealed Relays—Catalog 14 pp. Contains engineering data, description and listing of standard products. Hi-G Inc, Bradley Field, Windsor Locks, Conn.

(I-141) Electrical Cords—Catalog, 15 pp. Gives ratings and lengths of cord sets for electric ranges and dryers, industrial extension cords, and others. Cornish Wire Co, Inc, 50 Church St, NY, NY.

(I-142) Time Delay Relay—Bulletin, 4 pp. Gives operating specifications, contact capacity dimensions and electrical ratings. Miniature time delay relays are adjustable from .030 sec to 120 seconds. AGA Div, Elastic Stop Nut Corp of America, 1027 Newark Ave, Elizabeth, NJ.

(I-143) Storage Batteries—Bulletin, 4 pp. Provides selection data on batteries designed for starting stationary diesel and gasoline engines, supervisory control, emergency lighting, and switch tripping. Descriptions of its function and construction. Nicad Div, Gould-National Batteries, Inc, 172 Pleasant St, Easthampton, Mass.

(I-144) Capacitors—Catalog, 48 pp. Listing of capacitors and resistors used in industrial electronic equipment. Contains specifications, photographs, circuit diagrams and prices. Sprague Products Co, Marshall St, North Adams, Mass.

(I-145) Electrical Connectors—Catalog, 12 pp. Describes basic assemblies, nomenclature, typical applications and contact arrangements. Includes information on push button switches and cable vulcanizers. Electrical Products Div, Joy Mfg Co, 1201 Macklind Ave, St Louis 10, Mo.

(I-146) Switches—Catalog, 88 pp. Describes and illustrates variety of differential and absolute pressure actuated switches; gives engineering and application information, design, construction, and other technical data. Also includes information on snap-action switches, solenoids, and portable test bench. Meltron Corp, 950 N Highland Ave, Los Angeles 38, Calif.

(I-147) Magnetic Amplifiers—Bulletin, 4 pp. Gives specification data on various sizes of high power magnetic amplifiers for output range from 515 through 32,500 v-amp. Vickers Inc, Electric Products Div, 1815 Locust St, St Louis 3, Mo.

(I-148) Tube Cooling Shields—Brochure, 4 pp. Describes shields with full contact liner; gives application data, dimensions, materials, finishes and typical values. Atlas E-E Corp, 47 Prospect St, Woburn, Mass.

(I-149) Thyratron Tubes—Bulletin, 1 pp. Tube selection guide and summary of ratings of thyratron and rectifier tubes. Electrons, Inc, 127 Sussex Ave, Newark, NJ.

(I-150) Electrical and Electronic Components—Catalog, 98 pp. Describes materials, finishes, specifications, ratings and parts; solder terminals, hardware, coil forms, and others are covered. Cambridge Thermionic Corp, 445 Concord Ave, Cambridge, Mass.

MD pres-SURE-blocks—DESIGNED for QUICK Assembly and EASY Changes

ANY NUMBER OF CIRCUITS—compact pre-assembled sections of 20 circuits (only 1-1/8" wide x 63/64" high)—no need to handle single pieces, just pull off or add groups of circuits as needed. Merely snap on a single end section to complete block.

HAND ASSEMBLED without fixtures or hardware: only 2 parts to handle, contact sections and end section; mounting screws required only every 12 circuits; channel mounting also available; choice of integral or separable marking strips.

LARGER CAPACITY IN LESS SPACE

#22 thru #8 (*or* equivalent combinations); conservatively rated at 750 volts; contacts on 7/16" centers; 3 types of contact sections for stripped or terminal-ended wires (can be combined in single block).

LENGTHEN IN SERVICE without removing mounting screws or losing any contact space.

USE FEWER CIRCUITS by grouping common wires in tubular contacts—decrease jumpering; eliminate unused contacts.

The Buchanan MD pres-SURE-block gives greater economy and maximum flexibility to the installation, wiring and field servicing of terminal blocks.

For detailed information, write for Bulletin PD-59

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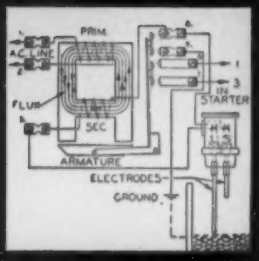
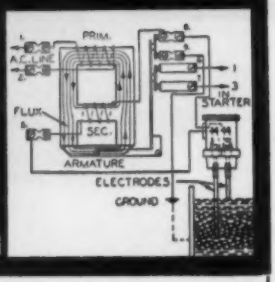
LIQUID LEVEL CONTROL with the B/W RELAY





Type LH Relay for Pump Down Control

POSITIVE AND DEPENDABLE

The B/W system of liquid level control consists of a transformer type induction relay and a holder for one or two electrodes, depending on the desired operation and the type of relay used. The relay incorporates a primary or line voltage coil connected to a permanent source of alternating current, and a secondary or electrode circuit coil connected to the electrodes immersed in the liquid being controlled. Energizing the primary coil causes an induced voltage in the secondary coil; thus the secondary coil is never connected to the power line.

LIQUID IS ELECTRICAL CONDUCTOR

The liquid itself is the electrical conductor that completes the secondary circuit. When this secondary circuit is completed, by the liquid contacting both electrodes, the magnetic attraction set up in the legs of the relay core causes the armature to close, and open or close the load contacts. A built-in holding circuit maintains this contact until a predetermined fall in liquid level breaks the circuit. By adjusting the electrode settings, the range of operation can be controlled.

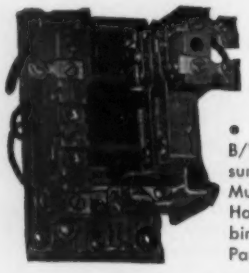
FOR PUMP UP and PUMP DOWN APPLICATIONS, SIGNALS and ALARMS

B/W relays are designed for either pump up or pump down operation. In addition, by using a single electrode they are well suited for signal and alarm applications.

NO MOVING PARTS

The complete absence of moving parts in the liquid insures long and trouble-free performance. Because of the very low current in the secondary circuit these relays are ideal for many switching jobs outside of the liquid level field.

Consult our engineering department on any special control applications.



CATALOG on request

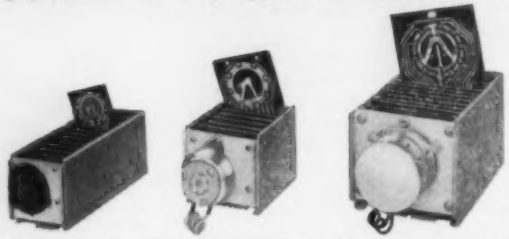
- It covers the complete line of B/W Induction Relays, Enclosures, Contactors and Starters, Multiple Pump Controls, Electrode Holders, Starter and Relay Combinations, Special Controls and Panels.

B/W CONTROLLER CORPORATION
2218 E. Maple Road, Birmingham, Mich.

FIRST IN THE FLOATLESS CONTROL FIELD

UNIQUE DESIGN ROTARY SWITCH— 5-SECOND WAFER REPLACEMENT

No Unsoldering or Disassembling . . . No Wire Removing . . . Simply Lift out Any Wafer & Replace Instantly . . . Highly Reliable—Presently Supplied for Military Applications



Reduces to seconds maintenance which otherwise could take a full day or more, saving valuable time. New design obsoletes old switches.

Switches are available in sizes approx. 2" x 2", 3" x 3" and 4" x 4" with lengths to accommodate up to 36 wafers. Virtually unlimited choice of switch circuit configurations. All connections are to a single bank of receptacles and are conveniently accessible from one side of the aluminum housing. Contacts are silver, gold or rhodium plated on a copper base. Wafers can be made to include printed circuitry and components in addition to their normal switching function.

Switches may be manually, motor or solenoid operated for use in any rotary selector switch application. Manufactured under Tabet U. S. Patent No. 2,841,660. Other U. S. and foreign patents pending. Write for details today.

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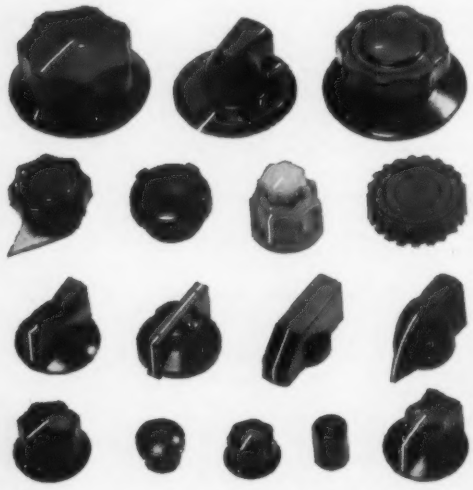

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catalogs and bulletins.....continued

(I-151) Silicon and Selenium Rectifiers—Brochure, 8 pp. Gives maximum ratings, performance curves, temperature derating table, half and full wave characteristics, and dc current rating chart of various electronic cell sizes. Tung-Sol Electric Inc, 95 Eighth Ave, Newark 4, NJ.

(I-152) Relay—Brochure, 4 pp. Describes wedge action contact principle for 6 pole double throw relay. No bounce or chatter characteristics at 30 g vibration level and 100 g shock level. Hermetically sealed 200 C application conforms to MIL-R-5757-C and MIL-R-25018 Class C, Type 2 Grade 3. Electro Tec Corp, 10 Romanelli Ave, South Hackensack, NJ.

(I-153) Flexible Conduit and Fittings—Catalog, 42 pp. Describes materials, specifications, applications and military part numbers of conduit and fittings for low tension circuits. Also, includes data on conduit collars, locknuts and swagging tools. Breeze Corp, Inc, 700 Liberty Ave, Union, NJ.

(I-154) Mercury-wetted Contact Relay—Bulletin, 4 pp. Gives electrical and mechanical specifications; provides mounting and wiring data as well as operating characteristics. C P Clare & Co, 3101 W Pratt Blvd, Chicago 45, Ill.

(I-155) Rectifiers—Bulletin, 1 pp. Describes high current grid controlled rectifiers and additional technical information available. Electrons, Inc, 127 Sussex Ave, Newark, NJ.

(I-156) Industrial Solenoid—Catalog, 28 pp. Details oil immersed, miniature and special models, ac or dc. Also includes force characteristics selection table. Detroit Coil Co, 2435 Hilton Rd, Ferndale 20, Mich.

(I-157) Control Transformers—Bulletin, 4 pp. Lists dimensions, shipping weights, inrush capacities and regulation characteristics of heavy duty dry type. Includes graphs and charts to aid in selection of the properly rated transformer. Hevi-Duty Electric Co, PO Box 563, Milwaukee, Wisc.

(I-158) Ferrite Magnetic Materials—Bulletin, 8 pp. Covers the nature, production, advantages and limitations, sizes, shapes and general applications up to 200 mc. Includes specification and selection charts. General Ceramics Corp, Crows Mill Rd, Keasbey, NJ.

(I-159) Motor and Circuit Protectors—Catalog, 32 pp. Circuit breakers and protectors for motors or electric circuits, both manual and automatic reset types. Mechanical Products, Inc, 1824 River St, Jackson, Mich.

(I-160) Transistor Curve Tracer—Bulletin, 4 pp. Describes construction and operation of instrument used to test signal level transistors. Lists types of measurements made, applications and engineering data. Magnetic Amplifiers, Inc, 632 Tinton Ave, NY 55, NY.

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A deviation from one of our standard switch assemblies will give you a *special switch* at a standard-switch cost.

Over 90% of our production is *special* in one way or another.

These standard switches can be modified to fit your application:

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- *Type AF* — up to 8 positions, 6 sections maximum, detent action, rating with resistive load 5 amp. at 28 volts d-c or 115 volts 400 cps, per MIL-S-6807.
- *Type P* — Multi-section, up to 4 positions, snap-action, rating 10 amp. 125 volts a-c, 5 amp. 125 volts d-c, 30, 60, 100, 200 amp. 500 volts a-c, or 250 volts d-c. Can be assembled to meet Specification MIL-S-15291.
- *Type JR* — up to 8 positions, 30 sections maximum, detent action, rating 10 amp. 125 volts a-c, 5 amp. 125 volts d-c.
- *Type JD-JS* — up to 8 positions, 5 sections maximum, detent action or snap action, rating 30 amp. 230 volts a-c.
- *Type HT* — up to 16 positions, 10 sections maximum, detent action, rating 5 amp. 125 volts a-c.
- *Geared-Pair Type HT* — up to 16 positions, 20 sections maximum, detent action, rating 5 amp. 125 volts a-c. A single knob controls two Type HT switches assembled with a gear mechanism.
- *Navy Switches* — to MIL-S-15291 and Bureau of Ships drawings 9000-S6202-73075, 73826, 73827, 73295, 74422, and others.

Write for data sheets on individual switches or complete new catalog on ESCO rotary multipole switches. Send us your requirements and we'll give you full specifications on the ESCO switch that meets *your* need.

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'DIAMOND H' RELAYS

NEW . . . High Speed Polarized Relays

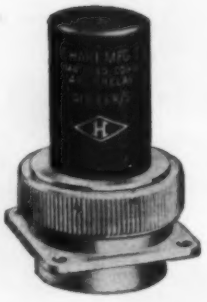
Fast action with freedom from bounce, plus high sensitivity and consistent operation with low distortion, are provided by small, rugged Series P Polarized Relays. SPDT, with two independent coils, they will handle over 1,000 pulses per second. Various coil resistances up to 5,000 ohms each coil. Contact ratings vary with switching speed but range from 60 MA to 2A with voltages to 120 AC or DC, dependent upon amperages employed.

Aircraft-Missile Series R & S Relays

Miniature, hermetically sealed 4PDT, Series R & S relays provide excellent reliability over their long service life. Electrically and physically interchangeable, the two series differ only in that Series S coils are separately sealed within the sealed cases, with organic matter eliminated from the switch mechanism for greatest reliability in dry circuits. Contacts MA to 10 A.

Special Mountings

Series R/S Relays are available with 10 standard mounting arrangements, plus a ceramic plug-in socket. MS-AN type connector mounting, illustrated at right, makes assembly, installation and field service extremely simple, while the connector provides a seal against moisture.



"Diamond H" engineers are prepared to work with you to develop variations on these relays to meet your specific requirements. Tell us your needs . . . by phone or letter.

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For fast heat-up, high-density heat, HOTWATT Precision Cartridge Heating Units are tailor-made to solve your problem. HOTWATT's unique production system offers a wide range of standard heating units . . . in diameters from 1/8" up . . . with lengths, wattage and voltage to meet your requirements.

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NEW CARTRIDGE HEATER GUIDE helps you get heat in a hurry

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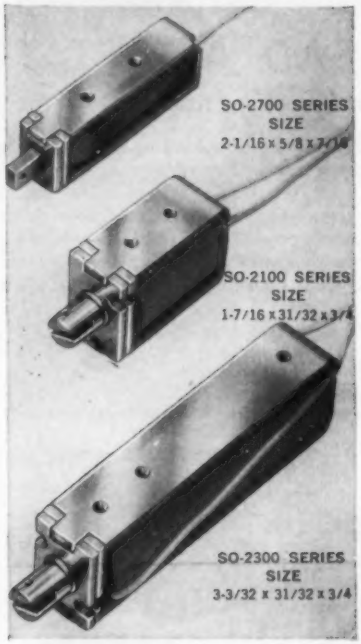
ELECTRICAL AND ELECTRONIC COMPONENTS I

POLLAK JP
STANDARD D-C SOLENOIDS



- MINIATURE, LIGHT WEIGHT, COMPACT
- MAXIMUM POWER FOR MINIATURE SIZE
- VARIETY OF MOUNTINGS, COILS, WIRE SIZES
- PLUNGERS DESIGNED FOR PUSH OR PULL

High magnetic efficiency results in an unusual power-to-size ratio making these solenoids ideal where miniaturization is important. General applications include: automatic process control, automatic machinery, communications, automation and computation.

As a design aid for applications involving linear solenoids write for new Brochure which includes detailed procedure and all pertinent information necessary for determining the proper solenoid. Included are: graphs of force-stroke, temperature rise-power, temperature rise-time and tables of standard coil resistances.

Pollak also offers a wide variety of special and standard relays, solenoids and switches.

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catalogs and bulletins.....continued

(I-161) Dc Power Supplies—Catalog, 12 pp. Application data, standard outputs, electrical and mechanical specifications, and prices for laboratory and modular power supplies with rack or bench type mounting. Dressen-Barnes Corp, 250 Vinedo St, Pasadena, Calif.

(I-162) Insulated Wire and Cable—Catalog, 23 pp. Gives voltage ratings, weights, stranding, lengths, insulation thickness and approved usages of power supply cable and cord sets, arc welding and control cables. Carol Cable Co, Div of the Crescent Co, Inc, 190 Middle St, Pawtucket, RI.

(I-163) Resistors—Catalog, 9 pp. Gives electrical ratings, dimensions, resistance values, temperature coefficients and military specifications of nickel chromium metal film resistors. Includes description of its electrothermal construction. Weston Instruments, Div of Daystrom, Inc, 614 Frelinghuysen Ave, Newark 12, NJ.

(I-164) Rotary Multipole Switches—Catalog, 16 pp. Describes snap and detent action types with ratings up to 200 amp; includes exploded views, dimensions, contact diagram, ordering information. Electro Switch Corp, 167 King Ave, Weymouth, Mass.

(I-165) Reels and Collector Rings—Catalog, 32 pp. Describes various types of reeling devices, handspring and motor driven, for electric cord and cable, hoses and balancing devices. Includes selection tables, capacity and rating charts. Industrial Electrical Works, Inc, 1509 Chicago St, Omaha, Neb.

(I-166) Slip Ring Assemblies—Catalog, 14 pp. Describes ring, brush and insulating materials, maximum operating characteristics, applications and wire lead specifications. Dimensional drawings and specifications are included. Breeze Corp, Inc, 700 Liberty Ave, Union, NJ.

(I-167) Selector Switch—Brochure, 4 pp. Describes 10 position ultra-low torque precision selector switch in two standard configurations. Contains parts list, typical wiring diagram, application and special design information. Electro Tec Corp, 10 Romanelli Ave, South Hackensack, NJ.

(I-168) Timing Devices and Motors—Catalog, 36 pp. Application data and specifications for variety of electrical, electronic and electro mechanical timing devices and motors. Repeat cycle and interval timers, elapsed time indicators, and others. The A W Haydon Co, 232 N Elm St, Waterbury, Conn.

(I-169) Multi-station Switches—Catalog, 6 pp. Contains specifications, part numbers and prices of nonilluminated and illuminated types, from one to 37 stations. Switchcraft, Inc, 5555 N Elston Ave, Chicago 30, Ill.

(I-170) Extension Cable—Catalog, 4 pp. Describes uses, advantages, calibrations, color coding and types available. Thermo Electric Co, Inc, Saddle Brook, NJ.

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These relays have recently been re-designed—improved in performance *and* appearance. So you'll want up-to-date specs.

This free folder gives complete details on all models. In it you'll find operating specs, timing ranges, contact capacities, dimensions, diagrams of contact and terminal arrangements, and data on mounting and installation accessories.

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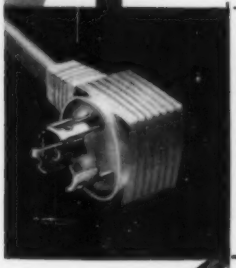
Takes the strain off the wire — and adds a smart useful look to any electrical product — available in a variety of sizes and designs. Patented.



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Seal rim — an integral part of the plastic form — keeps out foreign matter and moisture.

Heavy duty STRAIN RELIEF
Designed for use on portable tools, appliances, etc. Our mold set-ups are flexible, permitting infinite variety of nose section shapes and dimensions.

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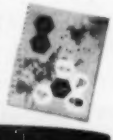
Stock components are illustrated in our 55 page catalog. Write for copy now — and be included on mailing list for supplements as issued.



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catalogs and bulletins.....continued

(I-171) General Purpose Relay—Brochure, 8 pp. Contains specifications, contact combinations, mounting arrangements and operating principles of advanced design general purpose relay. Hart Mfg Co, 273P Bartholomew Ave, Hartford, Conn.

(I-172) Electrical Components—Catalog, 160 pp. Contains prices, capacities, ratings and electrical specifications for circuit breakers, panelboards, starters, relays, push button stations, switches, and others. Includes selection tables and code requirements. Square D Co, 6060 Rivard St, Detroit 11, Mich.

(I-173) Terminals—Catalog, 24 pp. Illustrates various styles of plain and locking terminals. Dimensions, materials, finishes and ordering data are given. Shakeproof Div of Illinois Tool Works, St Charles Rd, Elgin, Ill.

(I-174) Polarized Relay—Bulletin, 2 pp. Describes high speed polarized relay for electronic and communication applications that can exceed 1000 cycles per second. Hart Mfg Co, 273 P Bartholomew Ave, Hartford, Conn.

(I-175) Electrical Insulating Materials — Brochure, 8 pp. Lists various grades and specification standards for tubing and sleeving products. Construction materials and thermal limitations are also given. Sample pieces of tubing and sleeving are attached. Varflex Corp, 512 W Court St, Rome, NY.

(I-176) Transistorized Voltage Regulator—Bulletin, 9 pp. Schematic diagrams and photographs illustrate the control principle, mounting, selection and servicing of transistorized voltage regulators. Lake Shore Electric Corp, 205 Willis St, Bedford, Ohio.

(I-177) Potentiometers, Resistors and Switches—Catalog, 70 pp. Gives specifications, outline drawings, output curves, performance data and ratings for various models. Clarostat Mfg Co, Inc, Dover, NH.

(I-178) Protective Relays—Catalog, 16 pp. Gives details on construction, features, applications and engineering data. Federal Pacific Electric Co, 50 Paris St, Newark, NJ.

(I-179) Wire and Cable—Bulletin, 4 pp. Shows wide line of molded plugs, connectors, cord sets, insulated wire and custom molded assemblies. Miller Electric Co, 120 Main St, Pawtucket, RI.

(I-180) Electrical Footswitches—Catalog, 4 pp. Describes various models and types, circuit arrangement, ratings, size, weight, stage, contact type and specific features. Linemaster Switch Corp, PO Box 52, Woodstock, Conn.

(I-181) Appliance Switch—Catalog, 4 pp. Describes construction and operating characteristics. Diagrams, ordering information and discount schedule are included. Cherry Electrical Products Co, 1650 W Deerfield Rd, Highland Park, Ill.

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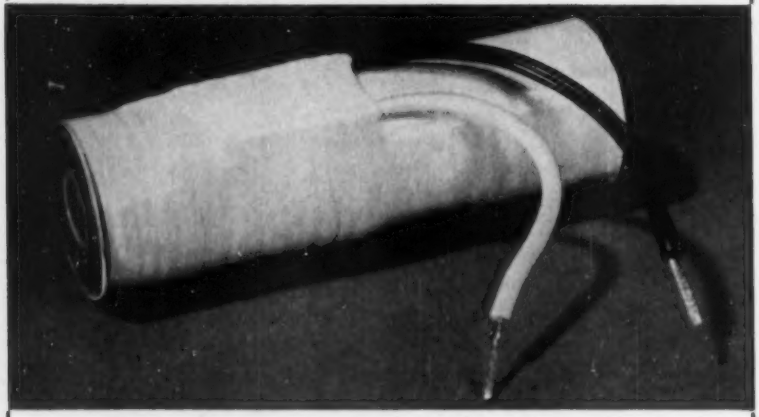

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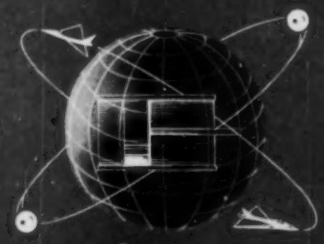
Men who read more...earn more!

SECTION J

HYDRAULIC AND PNEUMATIC EQUIPMENT



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DESIGN ABSTRACTS

HOW TO SELECT VALVES

Choosing the right valve characteristic is a matter of utmost importance in many processes, especially those needing close, stable control and having small holdup times. The author has organized a set of rules that enables the control engineer to select the best valve characteristic with respect to the static and dynamic effects of the disturbing variables. His articles traces the development of the selection rules—grouped in a table for future reference and use—and concludes by showing how to determine the best valve characteristic for four types of recurring process control problems.

"A Fresh Look at Selecting Control Valve Characteristics," Jake E Valstar, C F Braun & Co; Control Engineering, Mar '59, 330 W 42nd St, New York 36.

*

Hydraulic Tables

This booklet is intended for those engaged in the design or in the use of hydraulic equipment—particularly those structures involving the use of hydraulic pressures for load producing purposes.

Data have been collected from many sources, have been tested by experiment and by field experience over long periods.

"Hydraulic Tables and Other Data," Bulletin 3300, The Baldwin-Lima-Hamilton Corp, Hamilton, Ohio.

*

Hydraulic Fundamentals

This bulletin deals with the use of oil, not water, as a "hydraulic medium" in power presses, machine tools, molding machines, and many other types of equipment in which oil is used to transmit force and motion. Generally, oils designed for such use are called "hydraulic oils."

Basically, all hydraulic systems are exceedingly simple; they have fewer than half a dozen principal parts. In many machines, however, these basic parts are used in two's and three's, and their interrelation is complex.

"Hydraulic Fundamentals and Industrial Hydraulic Oils," Sun Technical Bulletin B-4 (1957 Revision), Sun Oil Co, Philadelphia 3.

*

Pneumatic Positioners

With today's ever-increasing emphasis on improved dynamic performance of industrial control systems, intensive attention is being focused on final-control element actuators and positioners; for, traditionally, the final control element has been the least responsive part of the control loop. And, just as a chain is no stronger than its weakest link, so also the control loop is no more responsive than its most sluggish member. Therefore, if there is to be any improvement in the dynamic performance of control systems, it must begin with improvement in the response of final control elements.

The article explains the factors affecting pneumatic positioner frequency response and is presented with a minimum of mathematics. An easy way to optimize the response of existing valve positioners is also described.

"Improving the Dynamics of Pneumatic Positioners," C. L. Mamzic, Moore Products Co; ISA Journal, Aug '58, 313 Sixth Ave, Pittsburgh 22.

*

High-temperature Hydraulics

The metallurgical factors controlling the use of metals for hydraulic applications in the temperature range of 400 to 900 Fare discussed. The materials available were appraised and some of the service experiences were related. It appears that a number of materials will be satisfactory for these applications. For highly stressed and wear parts, tool-steel-grade steels show promise. The cast irons show satisfactory structural stability in the foregoing temperature range for some wear applications and for structural parts and bodies. The nonferrous alloys must be selected with great care, since the temperature range of their usefulness is limited. Recent literature indicates that some improvements are forthcoming; however, most of the data are from the early stages of investigation.

"Metallurgical Factors in the Design of Hydraulic Equipment for Elevated Temperature Application," A Mars, Vickers Inc, and N M Lazar, Wayne State University; ASME paper no. 59-AV-11, ASME, 29 W 39 St, New York 18.

*

High-temperature Seals

Investigation of silicone rubber compounds for static seal applications has demonstrated the importance of tests to evaluate these materials for specific properties at environmental temperatures which simulate anticipated service requirements. Some relationships have been established between these properties and compound composition; they are presented as a guide for the selection of suitable materials for specific seal applications.

"Properties of Silicone Rubber for High Temperature Static Seals," H E Todd and J F Miazga Pratt & Whitney Aircraft Div, United Aircraft Corp; SAE paper no. 50V, SAE, 485 Lexington Ave, New York 17.

*

Fluid-control Valves

A single, universal rating sheet for fluid-control valves—if such a thing were practical or even possible—would need spaces for over 800 entries. After all, there are at least two dozen valve types in the fields of pneumatics and hydraulics, and several dozen important functions and limits for each.

But the problem is now being attacked logically by NFPA. From preliminary meetings of the special valve-rating committee, this much can be predicted: An effort will be made to bring orderliness to specifications and

catalogs. The systematic approach suggested in this article shows the type of information a product designer must get before he can judge available valve designs. Such data should be consistent, based on tests standard for all manufacturers.

However, a single rating in each category is not enough; supplementary data, curves and qualifying statements are often essential. Also, don't count on any more adjustment range than the valve rating specifies. If margin is wanted in a circuit, pick a valve with a wider rating, but remember that adjustment accuracy is lessened as range increases.

These examples explain why ratings are rarely simple:

1. The pilot chamber in some compensated reducing valves cannot withstand as high as pressure as the main chamber can.
2. Flow and pressure drop for a 4-way directional valve will probably differ with each variation of spool position, flow direction and porting arrangement.
3. Minimum controllable flow rate of a flow-control valve is affected by pressure level.
4. A flow-control valve with free reverse flow will have different ratings in each direction.
5. A flow or directional valve depends on the pressure drop to pass fluid, but it is the external circuit that limits the allowable drop.

"To Meet the Need—Better Ratings for Fluid-Control Valves," John J. Pippenger, Brown and Sharpe Mfg Co; Product Engineering, June 22 '59, 330 W 42nd St, New York 36.

*

Hydraulic-tube Buckling

Here is how to design against the chance that a straight run of tubing or pipe will buckle under internal fluid pressure. The method assumes that the tubing acts like a fluid column, and it goes on to borrow from what we know about behavior of cylinders and solid columns. It is done with equations that predict the danger point—and they can be easily adapted from equations already in existence for non-fluid columns.

Experimental evidence is necessary for each set of conditions for any fluid column, because it is not clearly understood how hoop tension, bending stresses and end loads interact. This article provides new data for one type of fluid column—hydraulic tubing.

"Buckling in Hydraulic Tubing," William H. Cooley, Boeing Airplane Co; Product Engineering, May 11, '59, 330 W 42nd St, New York 36.

*

Fluid Sealing in Extreme Environments

Discussed are elastomers available for seals, and the related design criteria for various fluid systems and their respective environments. It is shown that properly designed seals fabricated from the fluoro-rubbers, offer a possible solution to many of the problems described.

"Fluid Sealing in Extreme Environments," A. A. LePera, Wright Air Development Center; SAE paper No. 50U, SAE, 485 Lexington Ave., New York 17.

*

Pneumatic Circuits

The article deals with pneumatic circuits, mostly of a simple nature, which illustrate in some measure the application of such valves, cylinders, etc. All the circuits are in diagrammatic form and in no instance is there denoted any means of air line lubrication or filtration although it must be taken for granted that in most cases this is necessary.

"Pneumatic Circuits," Mechanical World, Sept '58, 31 King St West, Manchester 3, England.

*

Labyrinth Seals

The leakage flow through labyrinth seals in turbomachinery has been the subject of increasing concern as refinements and advances in design are made. Accurate knowledge of seal leakage is necessary in at least three areas of design: (a) Estimating the effect of seal leakage on performance; (b) regulating the leakage flow required for cooling purposes; (c) determining the thrust-bearing load which is a function of the pressure drop through the seal.

"Labyrinth-Seal Leakage Analysis," W. Zabriskie and B. Sternlicht, General Electric Co; ASME paper No. 58-A-118, ASME, 29 W 39 St, New York 18.

*

Level-control by Electrical Capacity Measuring

Level-control system developed for petroleum refinery uses a transmitter near point of measurement and recording equipment in convenient location. Has been used for hot and cold liquids, granlar materials, corrorsive fluids, as well as for certain types of stream analysis.

"Versatile Capacity Measuring System for Level Control and Stream Analysis," Shawhan, Bachofer, Lerner and Wright, Sun Oil Co. Midyear Meeting, May 27-29, American Petroleum Institute, 50 W 50th St, New York 20.

*

Centrifugal Micromanometer

A micromanometer has been developed for measuring small pressure differences of 25 mm to 5 x 10^{-3} mm water gage, with errors of less than 1%. Robustly constructed and easily transported, the instrument can be applied to measuring air speeds in moderately unsteady flow and as a calibrating standard for other manometers.

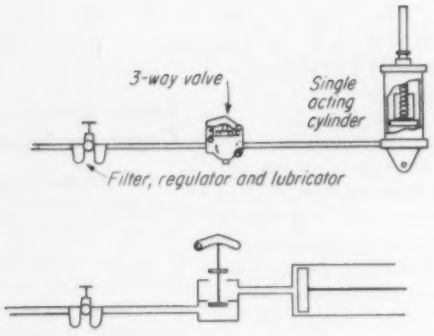
Pressure generator is operated by centrifugal forces acting on a number of radial air columns, in a rotating disk.

"Centrifugal Manometer," J. F. Kemp, S. African Council for Scientific and Industrial Research, ASME Paper 58-A-111.

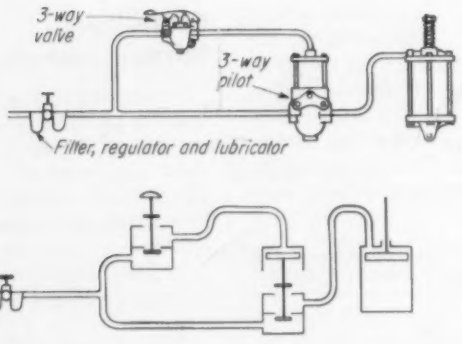
From: American Machinist

Assembly and Operation of Air Circuits

PHILIP HALL, Manager
Industrial Air Control Dept
A. Schrader's Son



Direct control–single-acting cylinder. . .
. . . is controlled by a 3-way valve. If the valve is normally-closed, the cylinder operates when the valve is operated and is spring-returned when the valve exhausts air to atmosphere.



Remote control–single-acting cylinder. . .
. . . requires a pilot valve placed in the circuit near the cylinder. This permits the delivery of a large volume of air instantly to a cylinder remote from a small control valve. Electrically controlled solenoid valve achieves the same result.

Compressed air is an inexpensive, reliable and safe source of power for actuating machine motions. A range of air-control devices are available to design any system. The following steps should be followed for assembly.

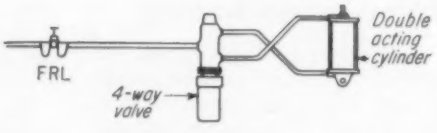
1–Break down the operational sequence into steps so that a single mechanical motion or air blast can handle each segment.

2–Make a schematic of the air-control system. Place a cylinder or air blast nozzle to handle each work step. Add, next, necessary time delays, remote controls and interlocks for each work steps.

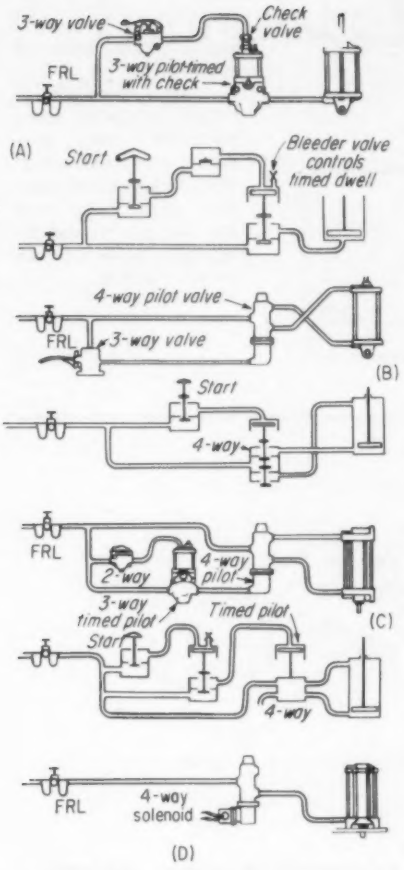
3–Means of actuation–manually operated valve, or a cam or roller operated valve if a mechanical motion will trigger the action. A system check should show all valves and pistons in the before action-start position.

4–Add auxiliary devices such as air filter or moisture trap in the supply line ahead of all valves and cylinders, air-line lubricator for rapid cycling or continuous movements, flow-control valves to adjust or speed piston movement as required, pressure regulator in cylinder supply line to adjust piston force.

REFERENCE:
How Air-control Devices Aid Production by Philip Hall, Manager, Industrial Air Control Dept, A. Schrader's Son, Division of Scovill Manufacturing Co., Inc., Brooklyn, New York. Published in American Machinist, Dec 15, 1958, p 109-116.

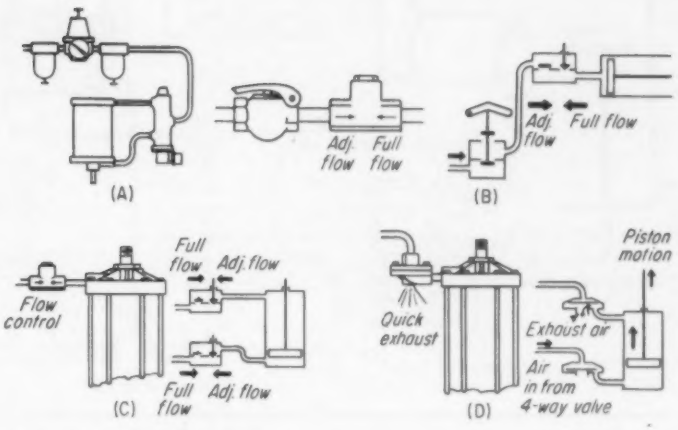


Direct or remote control–double-acting cylinder. . .
. . . is operated by a 4-way valve that charges one end of the cylinder while exhausting the other end. Operation reverses these connections. 4-way valve can be manually or pilot valve operated.



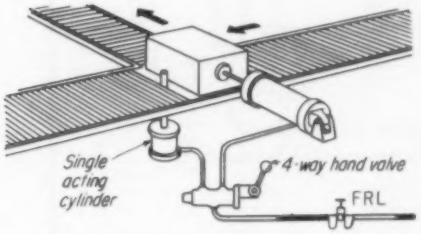
Time dwell of cylinder power stroke. . .

. . . can be held for a preset time by a timed pilot valve. (A) single-acting cylinder returns automatically after the time interval set at the pilot. Double-acting cylinder can be operated by (B) pilot valve without timer, (C) pilot valve with timer, or (D) a single or double solenoid valve.



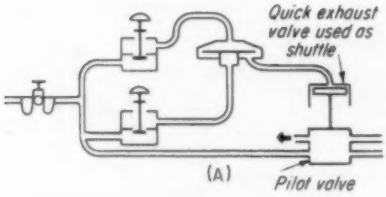
Location of control accessories. . .

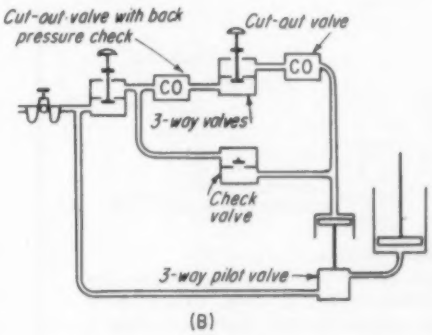
. . . should be as follows. (A) Filter, regulator and lubricator ahead of all control valves. (B) Flow control valves either before or after a 3-way control valve for a single-acting cylinder. (C) For a double-acting cylinder, control valves should restrict air flow in the reverse direction. (D) Locate quick-exhaust valves immediately next to cylinder connections.



Sequence air circuit—semi-automatic. . .

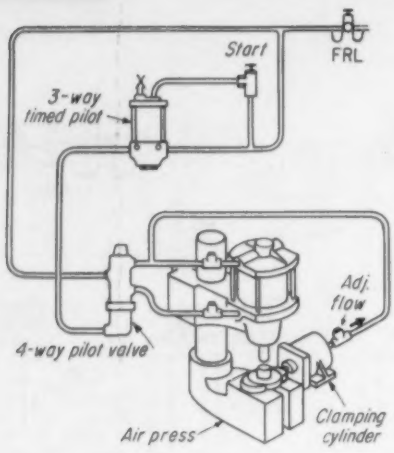
. . . permits operation alternately of two cylinders from one 4-way valve. Similar principle can be applied to double-acting cylinders. Several sequences of operation are possible. One could have the stop ram permanently engaged which would cause all material to be switched from one conveyor to the other. Another sequence would allow alternate units to be transferred. It is also possible to adjust the air circuit for manual operation or to remove from the system completely. This is needed for assembly line shut down.

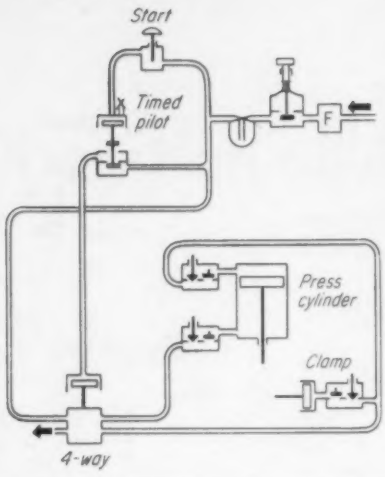




Combined air-control circuits. . .

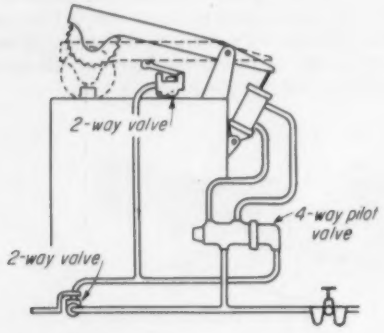
. . . for manual control. (A) Two-station control application of a single cylinder for door opening. Quick-exhaust valve is used as a shuttle for two paralleled 3-way valves. (B) Two-hand safety control on presses and similar machines. Removal of either hand discharges the system.





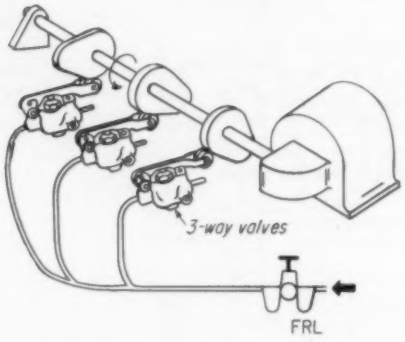
Sequence cylinder action—air controlled. . .

. . . has a timed pilot to control length of cycle. Cycle is: clamp, press slowly, return ram, release clamp. Flow-control valves delay press stroke until after clamp is set, and delay clamp release until ram reverses direction.



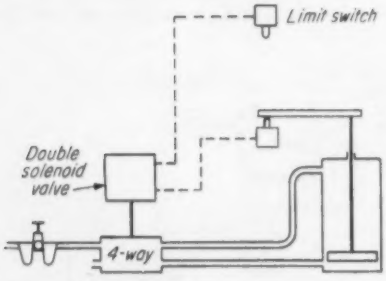
Single cycle feed and return. . .

. . . uses a 2-way foot valve to operate system in the working direction. A 2-way, normally closed limit valve returns system to next working stroke.



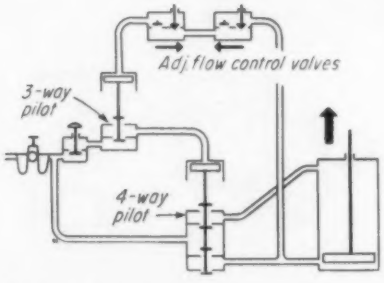
Sequence—cam controlled. . .

. . . permits accurate flexible control of cylinders. Slow-speed, motor-driven camshaft operates air valve in cycled sequence. A cam change will vary sequence operation.



Electrical limit switches. . .

. . . allow faster operation of reciprocating systems. Switches replace air valves. Cylinder is operated by a double-solenoid 4-way valve which is operated by the two limit switches.



Air-operated reciprocating system. . .

. . . has two flow-control valves that adjust the speed with which the 3-way pilot valve responds to reversals of the 4-way pilot valve. System permits independent dwell settings at both ends of the cycle or a fast return and dwell.

Hydrostatic Head of Liquids

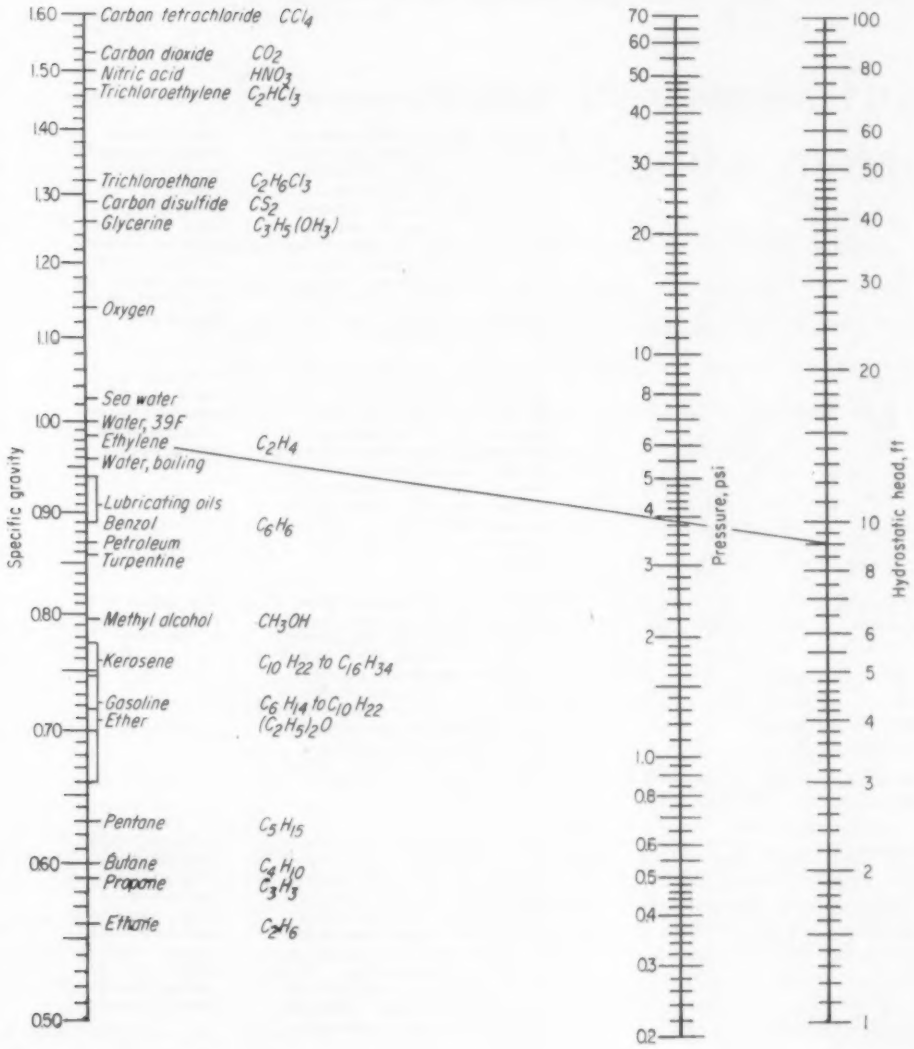
From: Power

S. SALVA
Jackson, Michigan

In designing equipment and piping it is often necessary to convert feet of head of a liquid into psi. The relationship depends on the specific gravity of the liquid. This nomogram quickly relates these three factors and lists the specific gravity for a large variety of industrial liquids.

Example: Find the pressure under 9 ft of ethylene. First, find the specific gravity of ethylene on the left hand scale; connect it with a straight line to 9.0 on the right hand scale. Find the answer at the intersection with the center scale, 3.9 psi.

REFERENCE:
Hydrostatic Head of Liquids by S. Salva, Jackson, Michigan. Published in Power, February, 1959, p 86. Data Sheet No. 318.



From: Electronics

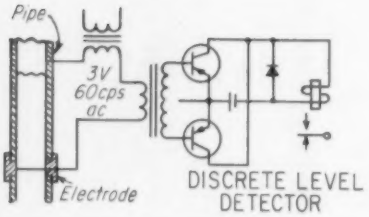
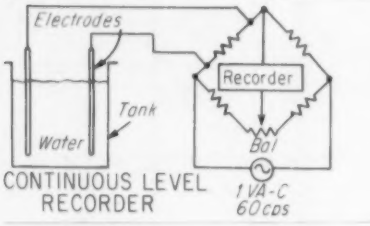
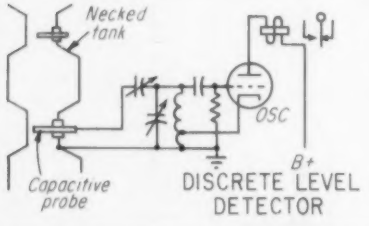
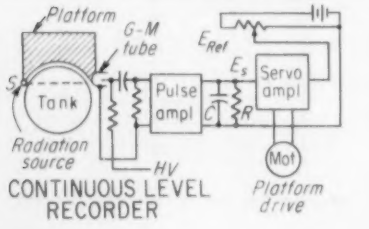
Liquid Level Detectors

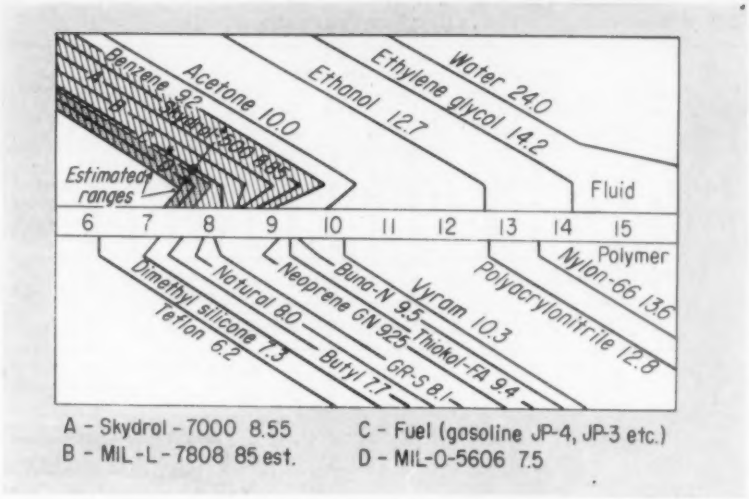
THOMAS L. GREENWOOD
Instrument Development Section,
Army Ballistic Missile Agency

Measurement of liquid level is often required in research and development problems. These frequently involve the calibration of turbine-type flowmeters. In this procedure a known quantity of liquid flowing through the flowmeter produces a known number of output voltage cycles which yields the flowmeter constant in gallons/cycle. This system requires accurate methods of discrete level measurement.

For other applications, continuous indication of liquid level may be desired. Here a system which operates either on the principle of electrolytic conductivity or capacitance change is suitable. Another method uses nuclear radiation absorption as a means of detection. The latter has been developed for use with liquids that are nonconductive such as liquid oxygen.

REFERENCE:
Liquid Level Detectors by Thomas L. Greenwood, Instrument Development Section, Test laboratory, Army Ballistic Missile Agency, Huntsville, Alabama. Published in Electronics, Jan. 2, 1959, p 49.

Type of System	Principal of Operation	Circuit Features	Characteristics
	Uses the principal of electrolytic conductivity. In general, the conductivity is a function of electrode size and shape and proportional to the area of surface contact between electrodes and liquid. A small dia wire (20 gage) is mounted in a pipe. When immersed in water, resistance changes from several megohms to a few thousand ohms. If multi-level indication is desired, electrodes can be installed at a number of heights.	Total resistance change in electrode circuit should correspond to small change in liquid level. Capacitance of cable and electrode dictates use of 60-cps ac voltage. Up to 200 ft of cable may be used.	With liquids of low conductivity, sensitivity sufficient for operation at resistivities up to 20 megohm—cm can be obtained with proper amplification.
	Parallel vertical metal rods are arranged to vary the impedance of one leg of an ac bridge circuit. Depth of immersion of the rods causes the proportional unbalance of the bridge and the unbalance current is used to drive an oscillograph recorder or galvanometer. The bridge circuit is balanced when the tank is empty and calibration made with static water levels.	Ac bridge supply should be used to avoid long time constants associated with dc supplies.	Used where high accuracy is not required. Capacitive component of electrode-liquid impedance causes nonlinear input-output relationship. Requires frequent calibration.
	Where the liquid being measured is nonconductive, such as liquid oxygen, a system based on capacitance change may be used. The detector is a capacitance electrode placed in a necked tank. When the electrode is immersed in the liquid, its capacitance to ground increases, and the vacuum-tube oscillator ceases oscillation. Output current goes to zero. When electrode is uncovered, oscillator current is normal.	Can be used as on-off control as well as limit-alarm.	Flowmeter calibrations accurate to 0.1 percent are obtainable with this method.
	Uses nuclear radiation absorption for non-conduction liquids. Platform shaped to fit contour of tank carries radium source S and Geiger tube. Path of gamma radiation is across chord of tank. Geiger tube output is train of pulses with frequency dependent on gamma energy. Pulses are integrated and compared to dc reference. Servo motor drives platform up and down to reduce error to zero.	Reference voltage is adjusted to equal integrated pulse voltage in center of range. Servo keeps platform at liquid surface. Multiturn potentiometer on platform drive gives remote indication.	No stuffing box or seal required in tank wall, so method excels for high-pressure service or in corrosive fluid measurements. Accuracy of system is about ±⅛ in.



From: SAE paper

Fig. 1—Solubility parameters of several typical liquids and polymers.

For Synthetic Hydraulic Fluids —which rubberlike material

Rubberlike materials are commonly used for seals and gaskets, flexible hose liners, line clamp cushions and accumulator diaphragms. Research has improved materials, processes, and techniques. In spite of these improvements, rapidly changing requirements impose new challenges. High temperature environments and new synthetic fluids are part of that new challenge.

E. A. WEBSTER
R. G. LARKIN
Testing Division, Douglas Aircraft Company

Selection of the most satisfactory rubberlike material for a particular hydraulic application depends generally on: (1) compatibility with the hydraulic fluids; (2) physical properties; and (3) performance and endurance requirements.

Included in these broad categories are problems related to functional environments such as resistance to heat and aging, low temperature flexibility, frictional properties, and wear.

COMPATIBILITY

Of the two methods for predicting compatibility—similarity rule and solubility parameter concept—the latter is considered more valuable. It is, in part, a quantitative index of the resistance of a rubberlike polymer to the entire spectrum of fluids.

Similarity rule states generally that members of a given class of organic components would usually be somewhat soluble, if not completely miscible in other members of the same class of compounds. Hence, natural rubber swells in similar hexane, polyvinylalcohol is water soluble, and GR-S is soluble in toluene. Unfortunately, the rule ignores insolubility, or resistance of a polymer to a liquid.

Solubility parameter gives a numerical index by which resistance as well as solubility can be predicted with reasonable accuracy. Solubility parameter is defined as the square root of the cohesive energy density, which is the energy of vaporization per cc of molecular volume of a liquid.

Parameter can be explained in terms of liquid-liquid interaction. As with other thermodynamic processes for systems in equilibrium these reactions follow the free-energy law:

$$\Delta F = \Delta H - T\Delta S$$

Where: ΔF equals free energy, ΔH is the heat of mixing, T equals temperature, and ΔS is entropy. The law predicts that a process takes place if ΔF is negative. To make ΔF negative, ΔH must be smaller than the $T\Delta S$; or the magnitude of $T\Delta S$ must be increased until it is larger than ΔH.

TABLE I—Compatibility of Elastomers with Fluids Based on Percent Swell

LEGEND				POLYMER TYPE														
Percent Swell	Evaluation	Symbol Observed	Symbol Est.	Silicone	Butyl	Natural	Buna-S (GR-S)	Neoprenes	Hypalon	Kel-F-Elastomer	Thiokols FA & ST	Philprene VP	Buna-N (Low nitrile)	Buna-N (High nitrile)	Acrylates (Hycar 4021)	Viton A	LS-53	IF 4 (FBA)	Vyram
0–15	Satisfactory	S	s																
16–40	Doubtful	D	d																
41–	Unsatisfactory	U	u																
FLUIDS																			
MIL-O-5606 (Hydrocarbon)				U	U	U	U	D	D	S	S	S	S	S	S	S	S	S	S
Engine Oil (Hydrocarbon)				U	U	U	U	D	D	S	S	S	S	S	S	S	S	S	S
OS-45 (Silicate)				U	U	U	D	S (1)	s	S	D (2)	d (2)	D (2)	D (2)	D (2)	S	U (2)	S	D (2)
MLO-8200 (Silicate)				U	u	u	d	s (1)	s	S	d (2)	d (2)	d (2)	d (2)	d (2)	S	u (2)	s	d (2)
Fuel, Gasoline, JP-4 (Hydrocarbon, Napthenics & Aromatic)				U	U	U	U	U	U	S	S	D	D	S	S	S	S	S	S
MIL-L-7808 (Diester, Organic)				D	U	U	U	U	U	U	S	D	D	S	S	D	U (2)	S	S
Skydrol-7000 (Phosphate)				S	S	D	U	U	U	U	U (3)	U	U	U	U	u	S	S	S
Skydrol-500 (Phosphate)				S	S	D	U	U	U	U	U (3)	U	U	U	U	U	S	D	S
Water				S	S	S	S	S	S	S	S		S	S	D (4)	s	S	D (4)	D (4)

(1) Types W, WRT and WHV only.
(2) If used above 300 F.
(3) Thiokol PR-1, no longer available, was satisfactory.
(4) In hot water.

NOTE: Many factors affect percent swell which are not reflected in the above tabulation. Consult manufacturer for accurate information on specific compounds.

Theoretically, heat of mixing is at a minimum when the solubility parameters of two liquids are equal. Empirically it has been determined that large interactions between fluids and elastomers are possible at 25 C if the solubility parameters are within 1.5 units or less of each other. Increasing the temperature will make the second term greater than the first, and give a negative ΔF value. This is a common method of assisting in the solution of a material in a solvent.

The position on the solubility parameter scale of several typical liquids and polymers is shown in Fig. 1. For immunity to swelling, the parameters should be as far apart as possible, and at least 1.5 units for most combinations at room temperature, and 3.0 or more at higher temperatures.

Several empirical facts are proved; for example, why natural rubber is worthless with hydrocarbon oils, and why benzene and toluene are popular solvents for natural rubber cements. Neoprene has a higher solubility parameter than natural rubber, and is much more resistant to hydrocarbon oils.

Nitrile rubbers exceed the 1.5 unit difference criterion required for resistance to most hydrocarbons. They are the most common elastomers used with fuels and with hydrocarbon hydraulic oils, engine oils and other hydrocarbon products. Also, the most compatible plasticizers for neoprene and nitrile elastomers are among the phosphate esters. Two typical phosphate fluids (Skydrol—7000 and—500) are close to neoprene and nitrile rubbers on the solubility parameter scale.

Butyl and silicone rubber are excellent choices for use with phosphate ester fluids. Vyram, in the opposite direction on the scale, is also excellent because of its high solubility parameter and is equally immuned to the hydrocarbon oils and fuels. Table I shows laboratory results for these and other polymers.

PHYSICAL PROPERTIES

Variations in compounding and curing are generally applied to obtain the optimum performance for a given application. Finished parts, however, are impractical to produce from experimental compounds, hence, certain arbitrary physical properties are determined. The assumption is made that good physical properties are related to good performance.

An example of the difficulty in applying generally accepted physical property criteria to new materials can be found by examining the attributes of three typical O-ring materials. Table II shows materials that satisfy the same functional requirements but

TABLE II–Typical Physical Properties of O-ring Materials

Property	Units	Material			
		Butyl	Silicone	Buna-N	
Hardness	Shore "A" points	75–80	75–80	68–73	AN5227 and AN6230 Type Dynamic Seals
Compression Set 70 hr at 212 F	Percent of original deflection	15–25	10–15	15–20	
Tensile Strength	psi.	1500	1000	1450	
Elongation	Percent elongation at rupture	300	225	210	
Volume Change	Percent	(1) 1– 8	(1) 7–14	(2) 1–10	
Hardness	Shore "A" points	87–92	80–85	87–93	AN5290 Type Static Seals
Compression Set 70 hr at 212 F	Percent of original deflection	15–30	15–20	20–30	
Tensile Strength	psi.	1600	990	1250	
Elongation	Percent elongation at rupture	200	125	170	
Volume Change	Percent	(1) 1– 8	(1) 5–10	(2) 1–10	

(1) Skydrol-500
(2) MIL-H-5606-A

are used with different fluids or in different environments.

Some of the reasons correlation between physical properties and performance is difficult are:

1) Specimens used for property measurements are often not identical to the O-ring or other functional test parts because of inadequate mixing, thermal variations, cure-time variations and surface-to-volume ratio.

2) Laboratory physical properties are not always measured under environmental conditions similar to those experienced by the functional part.

3) Some of the presently measured conventional physical properties may have no fundamental relationship with performance.

The first two, although recurrent, can usually be minimized by careful control over manufacturing variables or testing techniques. The last is directly concerned with the basic concepts of physical property measurements, and is important because it tends to place serious restrictions on establishing firm criteria for predicting the usefulness of a rubber material based upon easily obtainable physical measurements. Hardness, ultimate strength and compression set are all difficult properties to interpret in terms of performance requirements.

Hardness. The test for rubber hardness does not give a fundamental physical property, but is a crude manifestation of the resultant of several other real properties such as modulus, coefficient of friction and tensile strength. Inflexible hardness specifications can cause problems.

Nitrile rubber (Buna-N) packings, for example, used in O-ring seals for hydrocarbon hydraulic fluids work best when hardness is limited to 68 ± 3 Shore-A units. When a new fire-resistant hydraulic fluid was placed in service it developed that butyl was the preferred resistant elastomer and was concluded that the same hardness ratings should be used. After functional bench tests and service problems it became apparent that the best butyl stocks ranged in hardness from 70-80 Shore-A units rather than 65-71 for nitrile rubber. Hardness is now based on empirical performance as the measure of merit.

Ultimate tensile strength. Property is defined as the ratio of breaking load to original unstressed cross-sectional area of the specimen. It is a fictitious entity, though simple and convenient mathematically. Another definition, true tensile strength, is based on the actual cross section of the specimen at the moment of break. True tensile strength is calculated from ordinary tensile strength and elongation by the equation

$$S = S_e (E/100 + 1)$$

Rubber when deformed remains constant in volume through all ordinary loads. Thus, a specimen reduces in cross-section area as it is stretched to maintain constant volume. If, for example, elongation reaches 500%, the area becomes $\frac{1}{6}$ of the original area and true tensile strength will be six times the value usually reported.

Also, a single index of merit becomes possible while using two ordinary parameters. Using the conventional S_e and E, one decreases as the other increases, and it is difficult to choose the best properties.

Compression set. This is a measure of the amount by which rubber fails to recover from a prolonged deformation. Two standard methods are available: (A) constant load is applied through a spring to the specimen, and the result calculated in per cent of original thickness; and (B) specimen is clamped between two spacer blocks under constant deflection and the result determined as a percent of original deflection. Method B is more often used since rubber in service is usually compressed under constant deflection.

O-ring seals are exposed to a combination of constant load and constant deflection stressing. Constant load is caused by fluid pressure; constant deflection by the permanent side squeeze necessary for sealing at low pressure. In addition, the O-ring is stretched circumferentially, since the gland diameter is usually larger than the ring giving rise to simultaneous tension set.

Confusion exists because of the two test methods, the results of which are calculated differently. Some specifications require test method B, but desire the results to be calculated and reported as if both methods had been used. It must be realized that compression set data expressed as in method A, but calculated from a test performed in accordance with method B, is not to be compared in severity with a test actually performed as in method A.

REFERENCE:
Choosing Rubberlike Materials for Use With Synthetic Hydraulic Fluids, by E. A. Webster and R. G. Larkin, Testing Division, Douglas Aircraft Company. Presented at the 1959 SAE Annual Meeting, Detroit, Michigan, Paper No. 9T

Basic Designs in Fluid

From: Company Booklet

Hydraulic and pneumatic components can be combined in an infinite variety of ways to obtain special or standard control or cycle designs. Six basic designs are shown: two air; two-hydraulic and two combinations.

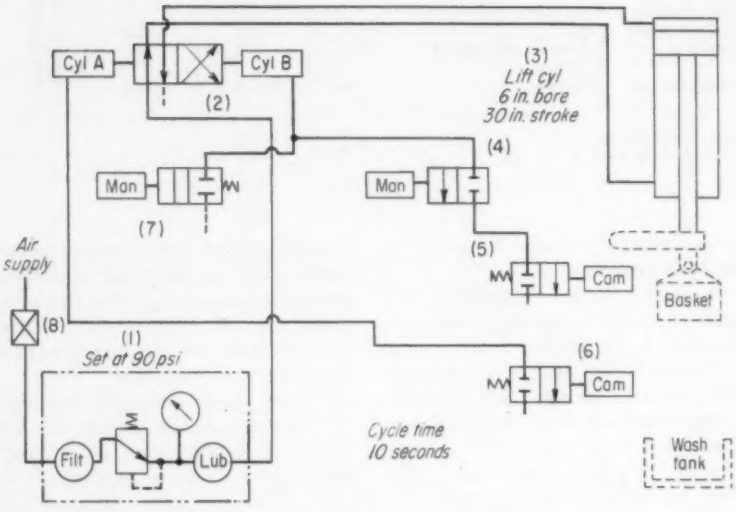
AIR CIRCUITS

Combination of semiautomatic and automatic cycle . . .

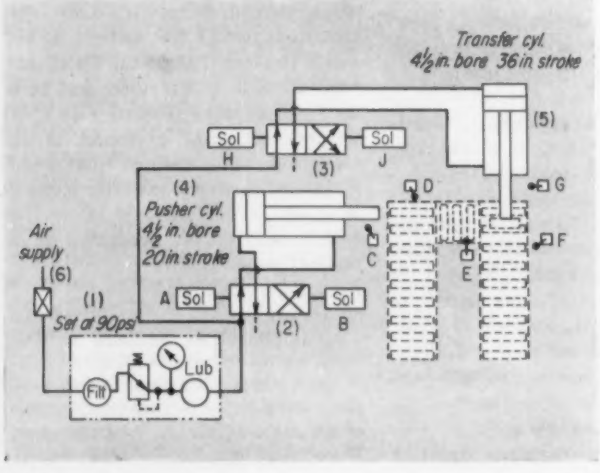
At start of cycle, lift cylinder (3) is normally in retracted or loading position. Once basket is loaded, handle of two-way valve (7) is tripped, bleeding air from cylinder B is four-way, two-position valve (2). This causes piston of valve (2) to shift and air to flow to blind end of cylinder (3) lowering the basket.

Piston of cylinder (3) advances until basket is submerged in tank, and cam on piston contacts and depresses cam roller on valve (6). This opens valve (6), bleeding air from cylinder A of valve (2) which causes piston of valve (2) to shift, allowing air to flow to rod end of cylinder (3). Piston of cylinder (3) retracts to original position.

If work is to be immersed several times, the handle of two-way valve (4) is shifted so that valve is in open position. Two-way valve (7) is then tripped, which bleeds air from cylinder B. Piston of cylinder (3) then reciprocates automatically as cam on end of piston rod depresses cam rollers on valves (5) and (6) until handle of valve (4) is returned to original position and the cycle restarts.



In the operation, the operator must unload the work and reload the basket before tripping the valve to restart the cycle. To automate, extra equipment would be needed.



Automatic cycle . . .

Workpiece moves down conveyor and contacts limit switch D, which energizes solenoid A of four-way valve (2), and air pressure flows into blind end of pusher cylinder (4). Limit switch E is contacted at end of stroke of cylinder (4), energizing solenoid B of valve (2) directing air to rod end of cylinder (4).

When rod of cylinder (4) is partially retracted, a swing type cam on carriage contacts limit switch C. This energizes solenoid H of valve (3) and air pressure is directed to blind end of cylinder (5). At end of out stroke of cylinder (5), limit switch F is contacted, causing solenoid J of valve (3) to be energized, and air pressure is directed to rod end of cylinder (5).

When piston of cylinder (5) reaches retracted position, limit switch G is contacted which allows current to flow to limit switch D to start the next cycle.

Power Circuits

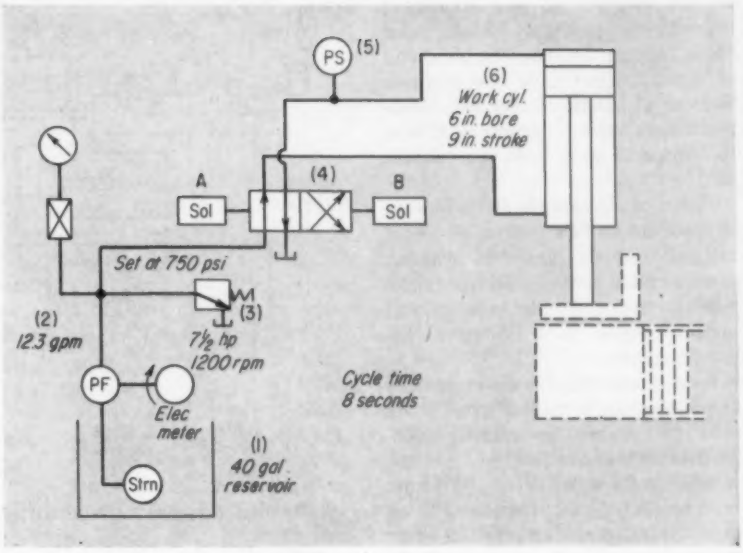
HYDRAULIC CIRCUITS

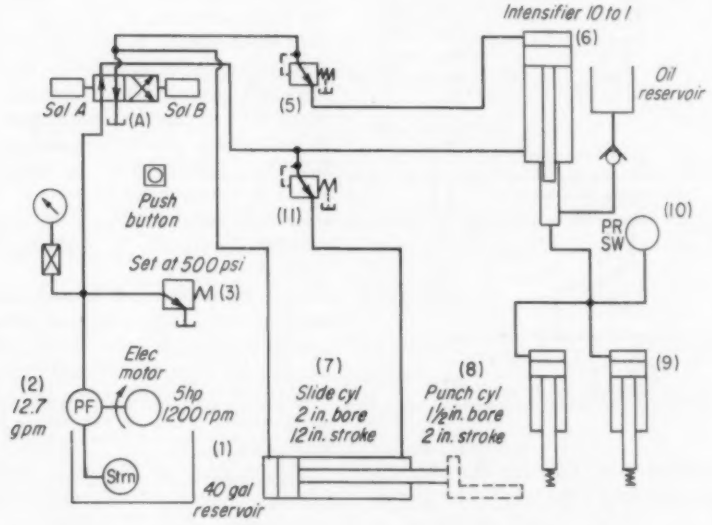
Semiautomatic cycle using pressure switch . . .

Workpiece is moved onto the transfer table from power conveyor. Solenoid A of four-way valve (4) is energized by start button. This shifts spool, directing oil pressure to blind end of work cylinder (6). Oil pressure moves work cylinder piston forward contacting workpiece and ejecting it from transfer table.

When piston of cylinder (6) reaches end of stroke, pressure builds up closing pressure switch (5). Closing of this switch energizes solenoid B of valve (4) causing spool to shift to original position. Oil pressure is directed to rod end of work cylinder (6) and piston is retracted completing the cycle.

The use of a pressure switch is one of many ways of effecting a semi-automatic cycle. There are many applications of semi-automatic cycles in automation applications. This is due to the fact that the addition of accessories to fully automate the cycle would be overly expensive and would probably introduce additional maintenance and engineering problems.





Circuit using intensifier to power punch cylinder . . .

Work is placed on slide cylinder table, and push button energizes solenoid A of solenoid-operated valve (4), shifting piston and allowing oil pressure to flow to blind end of slide cylinder (7). After piston of slide cylinder (7) moves to end of outstroke, pressure builds up, opening sequence valve (5), and oil pressure flows to blind end of intensifier (6), forcing its piston forward.

Intensifier pressure flows to single-acting punch cylinders (8) and (9). At end of punch stroke, full pressure builds up, closing pressure switch (10). This energizes solenoid B of valve (4), shifting piston, allowing oil to flow to rod end of intensifier cylinder (6), retracting piston, and allowing springs to return pistons of punch cylinders (8) and (9) to their original position.

When oil pressure builds up, sequence valve (11) opens, returning piston of cylinder (7) to original position. Pieces are unloaded and slide cylinder table reloaded for next cycle of the process.

Intensifiers are used to advantage where very high force is required in a limited space. It also eliminates costly high pressure pumps.

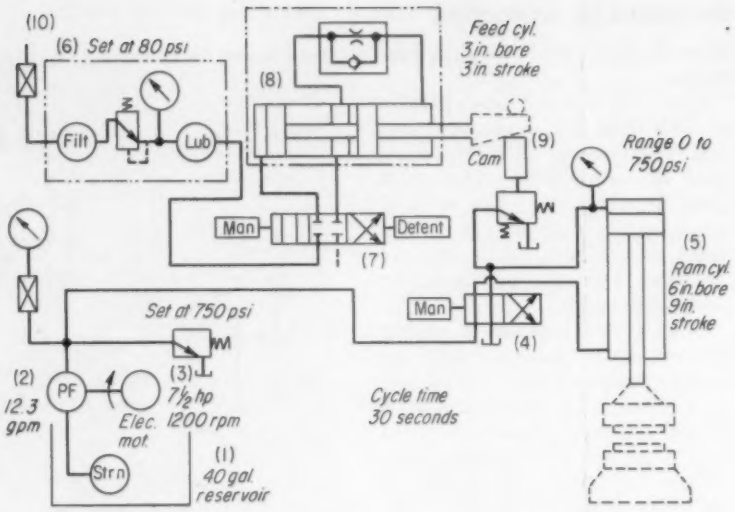
COMBINATIONS

Adjustable hydraulic pressure . . .

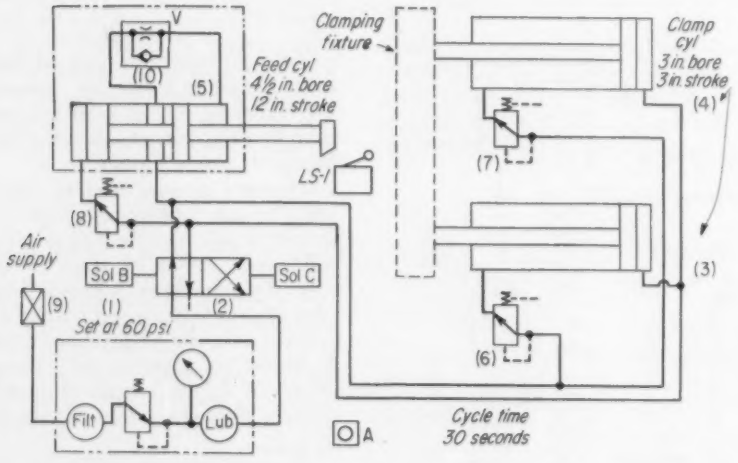
Work is loaded under die on end of ram cylinder (5) and handle of four-way, two-position hydraulic valve (4) is tripped. Oil flows to blind end of ram cylinder (5) at low pressure. Shifting of handle of four-way, three-position air valve (7) causes air to flow to blind end of air-hydraulic cylinder (8).

Piston of cylinder (8) starts forward at speed set by flow control on closed hydraulic circuit. On this cylinder, cam on end of piston rod contacts cam roller on hydraulic relief valve (9) and pressure begins to build up in hydraulic circuit.

Ram of cylinder (5) moves forward at pressure set by cam-operated relief valve (9). When air-hydraulic cylinder reaches end of stroke, full pressure is built up through valve (9). Pressure may be controlled by merely shifting valve (7) into neutral position anytime during outstroke of cylinder (8). To retract pistons of cylinders (8) and (5), handles of valves (7) and (4) are shifted.



With the minute feed of the air-hydraulic cylinder, pressures over the entire range of the relief valve may be obtained. This type of pressure control is important in many applications where air-hydraulics are used.



Combination fluid power circuits . . .

Depressing electric push button A, energizes solenoid B of four-way valve (2), which shifts its piston, allowing air to flow to blind end of clamp cylinders (3) and (4). Pistons move forward clamping work in fixture. Air pressure builds up in line operating sequence valve (8). Air flows to air-hydraulic feed cylinder (5) and piston moves forward. Speed of piston is controlled by needle setting of flow control in closed hydraulic system of hydraulic side or air-hydraulic cylinder.

When piston of cylinder (5) approaches end of stroke, limit switch (1) is contracted by piston cam which energizes solenoid C of valve (2). This shifts piston of valve (2) and air flows to rod end of cylinder (5) rapidly retracting piston due to opening of check valve in closed hydraulic system. When piston reaches original position, air pressure builds up opening sequence valve (6) and air flows to rod end of cylinder (3). Piston of clamp cylinder (3) retracts to original position.

Air again builds up in line, opening sequence valve (7), which is set at higher opening pressure than valve (6), and air then flows to rod end of cylinder (4), retracting piston to original position. System is now ready for next cycle.

Combination of air and air-hydraulic cylinders is ideal on clamp and feed circuits.

REFERENCE:

Basic Designs in Fluid Power Circuits. Published by Logansport Machine Co., Inc., Logansport, Indiana.

From: Power

Sealants For Fluid Control

W. M. LANGTON, Chemist, Permatex Co, Inc

A constant problem in all types of equipment is fluid leakage. It often demands expensive downtime of equipment. Besides, a leak can be potentially dangerous, both to operating personnel and equipment.

Sealants are now available that can be added directly to a fluid to seal leaks and reduce downtime expense. These sealants, according to government specifications, demand that a hole stop leaking within 10 seconds after introduction of the sealant.

Aqueous-system sealers—as the name implies—work only in closed liquid systems, not in gas lines. They will work with all liquids that will not attack the resin sealer and are not hampered by introduction of asbestos fiber into the system.

Classes. Liquid and paste sealants fall into three classes: hard-setting, flexible, and soft-setting. Hard-setting is used when a permanent seal is desired; flexible, where occasional dismantling is necessary or where vibration is a factor. Soft-setting compounds generally have a low viscosity, and are used primarily as pipe dopes.

Most sealants have some or all of these constituents: oils, resins, fillers, and solvents. Oils and resins will normally harden upon exposure to air to do the actual sealing. Solvents allow viscosity to be lowered for easy application. Fillers not only reduce final cost, but also add strength and hardness, heat resistance, insulation and a certain useful working consistency.

Selection. Four factors must be considered: (1) product to be sealed; (2) the working pressure; (3) the working temperature; and (4) all external environment conditions.

Sealants, after application and assembly, should not be affected by the fluids in the system. Do not use a water-soluble sealant for an aqueous system.

Hard-setting compounds are usually able to contain higher pressures, the exact pressure depending on pipe size, type of joint, and other factors. If a flexible or soft-setting compound must be used, special joints such as flared unions, are best.

Many sealants made with organic compounds will start to decompose at 400 F. Also hard-setting compounds tend to crumple as joint expands and contracts with repeated changes in temperature. If a standard sealant does not meet the requirement, often a special sealant can be manufactured. Generally, sealants for 400 F service will be more expensive because they are made to order and contain expensive ingredients.

On outdoor piping or exposed equipment lines be sure sealant is waterproof. Often, painting or coating over the sealant will be sufficient weather protection.

Application. Table shows the range of fluids that can be contained by the proper sealant. The sealants are characterized by their base material. Actually, extenders and modifiers such as inert fillers, often improve the sealant. They give desired body, added heat resistance and improved cohesion.

Fluids Contained by Proper Sealants

Materials to be sealed	Base of sealant
Acids	Chemically inert, low acid number and unsaponifiable type of resins—mineral rubber
Alcohols	Alcohol-insoluble synthetic resins and insoluble natural gums
Alkalis	Chemically inert, low acid number and unsaponifiable type of resins—mineral rubber and pitches
Aviation fuels	Insoluble natural gums and synthetic resins
Diester lubricants	Same as aviation fuels
Esters	Insoluble natural gums
Glycols (100%)	Insoluble natural gums and synthetic resins
Hydrocarbons, aliphatic	Insoluble synthetic resins, rubbers and polymerized heavy-bodied vegetable oils
Aromatic fluids	Insoluble synthetic resins and insoluble natural gums
Chlorinated fluids	Insoluble natural gums
Hydraulic fluids, petroleum based	Polymerized, heavy-bodied vegetable oils, insoluble synthetic resins and insoluble rubbers
Water glycol	Polymerized, heavy-bodied vegetable oils and insoluble synthetic resins
Phosphate esters	Insoluble natural gums
Ketones	Insoluble natural gums, and insoluble synthetic resins for higher molecular-weight ketones

REFERENCE:

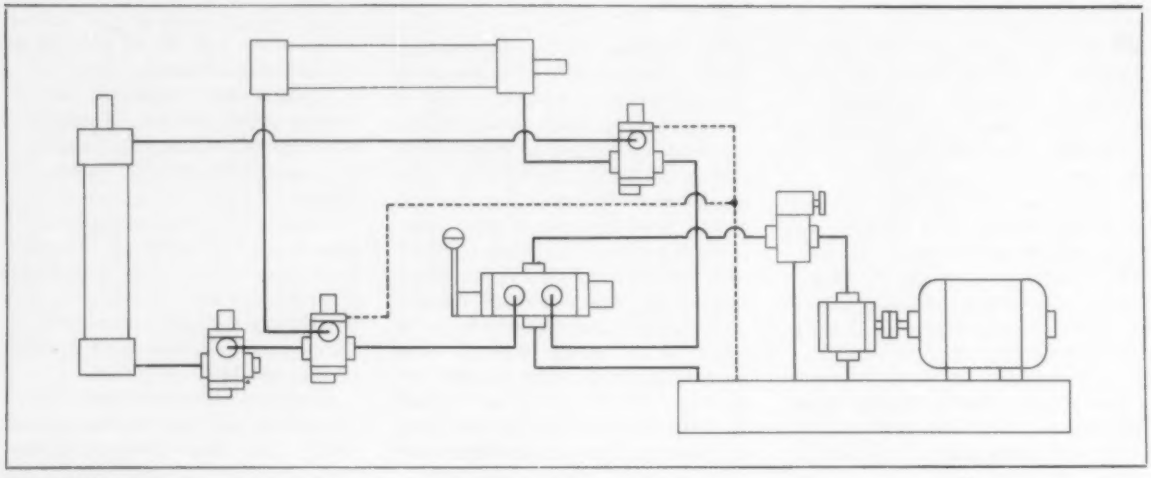
Knowing Your Sealant Can Save You Money by W. M. Langton, Chemist, Permatex Co., Inc. Published in Power, September, 1958, p 103-105.

Fluid Power

From: American Drafting Standards Manual

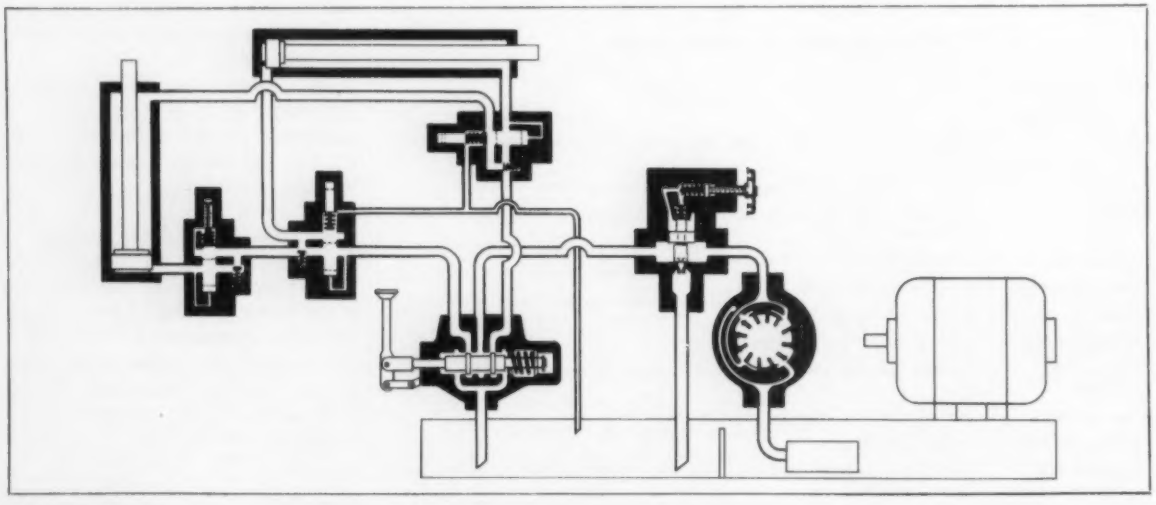
A drawing which depicts a hydraulic or pneumatic circuit for control or transmission of power differs in many ways from most engineering drawings. Explanatory notes and data are required to convey complete and proper information. Amount of information provided and type of diagram used depends largely on its intended purpose satisfying requirements for both supplier and user.

Four types of diagrams are covered: pictorial, used for quotation and piping the installation; cutaway, used for instruction purposes; graphical, used for quotation, piping the installation, and for analyzing circuit operation; and combination, used to emphasize purpose and operation of a portion of a system. Any or all may be required to satisfy requirements of supplier and user of equipment.



Pictorial diagram . . .

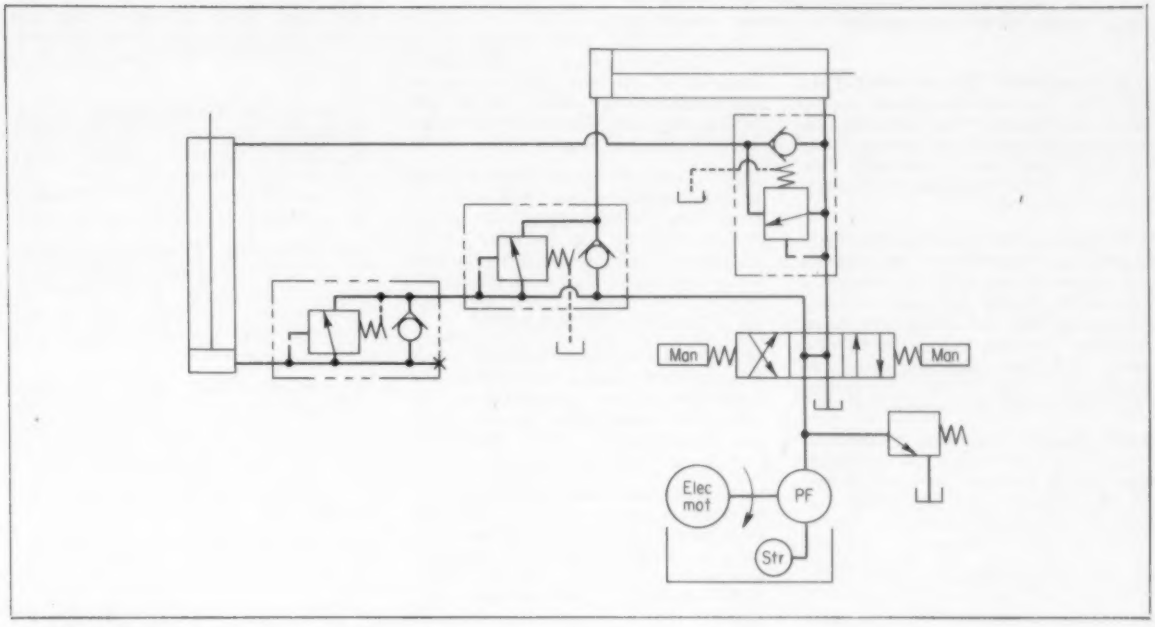
. . . is drawn with interconnecting lines joining the pictorial symbols of components. Diagrams of this type provide a simplified method of showing piping between components. General piping arrangement is emphasized. Circuit analysis is difficult with a pictorial diagram as only external features of components are shown.



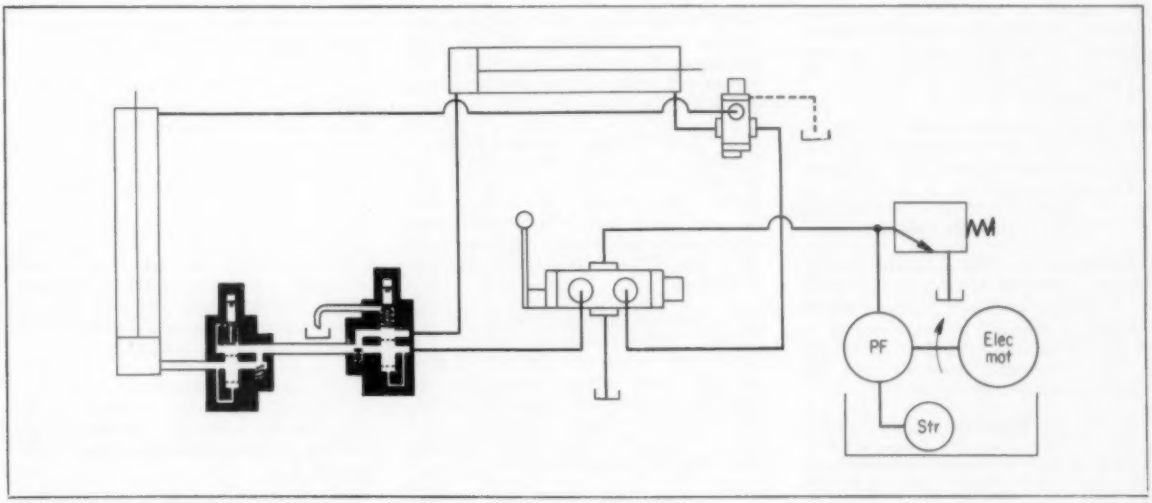
Cutaway diagram . . .

. . . is drawn with cutaway symbols of components joined with interconnecting lines. This diagram gives a means of showing principal internal working parts. Function of individual components is emphasized. Multiple drawings of this type are sometimes used to show position of moveable parts and flow paths during each phase of system operation.

Diagrams



Graphical diagram . . .
. . . is also drawn with interconnecting lines. Diagrams of this type provide a simplified method of showing function and method of operation of each component. Flow paths through the circuit are emphasized for each phase of system operation. Circuit analysis is, therefore, simplified for the supplier and user of the components.



Combination diagram . . .
. . . combines pictorial, cutaway, and graphical symbols and is drawn with interconnecting lines. Diagrams of this type provide a method of emphasizing piping, function, or flow.

REFERENCE:

American Drafting Standards Manual, ASA Y 14.17-1959, Section 17, Fluid Power Diagrams. Published by The American Society of Mechanical Engineers, 29 West 39 Street, N. Y.

CATALOGS and BULLETINS

To obtain copies of literature described below, write prefix letter and number on reader service card.

(J-1) **Thermostatic Control Valves**—Catalog, 8 pp. Illustrates the various types of valves manufactured. Also describes construction and applications; gives engineering information. Lawler Automatic Controls, Inc, 453 N MacQuesten Parkway, Mount Vernon, NY.

(J-2) **Filters and Strainers**—Catalog, 20 pp. Specifications, performance characteristics and application data on line of filters and strainers for liquids and gases including self-cleaning edge and wound wire types; disposable cartridge, porous metal and screen mesh types; diagrams, charts and illustrations. The Cuno Engineering Corp, 2020 S Vine St, Meriden, Conn.

(J-3) **Packaged Compressor Plants**—Brochure, 12 pp. Description of compressor units custom packaged to meet customer's requirements including details on standard components. Points out flexibility of packaged compressor plants for use in remote areas. The Stearns-Roger Mfg Co, PO Box 5370, Denver 17, Colo.

(J-4) **Actuators**—Catalog, 28 pp. Describes rotary, travel and torque limit, linear and dual electromechanical actuators; diagrams and technical engineering data. Barber-Colman Co, Aircraft Controls Div, Rock St, Rockford, Ill.

(J-5) **Hydraulic Components**—Catalog, 56 pp. Description, specifications on pumps, cylinders, valves, pressure switches and accessories. Data chart, ordering information. Oil-Dyne, Inc, 2115 W Marquette Rd, Chicago 36, Ill.

(J-6) **Pneumatic Components**—Catalog, 20 pp. Describes the complete line of pneumatic products. Engineering and operational data is presented to assist the designer. Watts Regulator Co, Industrial Div, 10 Embankment St, Lawrence, Mass.

(J-7) **Hydrostatic Transmissions**—Catalog, 32 pp. Describes variable and constant speed hydrostatic transmissions. Includes engineering data and outline drawings of various components. Sundstrand Hydraulic Div, Sundstrand Machine Tool Co, 2210 Harrison Ave, Rockford, Ill.

(J-8) **Air and Hydraulic Valves**—Bulletin, 8 pp. Outline of air and hydraulic valves from ¼ in. to 1 in. in size including manual, pilot and electrically actuated as well as special types. Beckett-Harcum Co, 985 W Locust St, Wilmington, Ohio.

(J-9) **Submersible Pumps**—Catalog, 8 pp. Contains illustrated applications, physical dimensions, pumping capacities, special features and electrical data on line of submersible pumps. Kenco Pump Div of The American Crucible Products Co, 1305 Oberlin Ave, Lorain, Ohio.

(J-10) **O-rings**—Brochure, 20 pp. Contains tables of standard sizes as well as dimensional data for installation. Also general recommendations on clearances, design material, finishes and machining for most o-ring applications. Special compound bulletin is also included. Linear, Inc, State Rd & Levick St, Philadelphia, Pa.

(J-11) **Power Cylinders**—Bulletin, 4 pp. Description of standard and special air and hydraulic cylinders, specifications, and other data. Anker-Holth Div, The Wellman Engineering Co, 2723 Connor St, Port Huron, Mich.

(J-12) **Lube Line Alert**—Brochure, 2 pp. Flow actuated device that electrically signals that each pump on a force feed lubricator is operating satisfactorily regardless of conditions. Manzel, A Unit of Houdaille Industries, 315 Babcock St, Buffalo 10, NY.

(J-13) **Centrifugal Pumps**—Catalog, 24 pp. Describes features and performance curves of close-coupled and base mounted pumps of standardized design and construction. Taco Heaters, Inc, 1160 Cranston St, Cranston 9, RI.

(J-14) **Actuators**—Bulletin, 6 pp. Features, construction, applications and mounting dimensions for air-hydraulic actuators and electric tachometers. Electro-Mechano Co, 261 E Erie St, Milwaukee, Wis.

(J-15) **Flexible Metal Hose and Fittings**—Catalog, 22 pp. Describes diversified line of flexible metal hose and fittings in bronze, stainless and carbon steel; sizes $\frac{1}{16}$ in. through 6 in. Gives construction details and applications. Packless Metal Hose, Inc, 730-45 S Columbus Ave, Mt Vernon, NY.

(J-16) **Solenoid Valves**—Catalog, 23 pp. Packless solenoid operated valves. Describes construction and applications; gives pressure ratings power consumption, dimensions and ordering information. Also, flow tables for various fluids and pipe sizes. Magnatrol Valve Corp, 67 Fifth Ave, Dept B, Hawthorne, NJ.

(J-17) **Control Valves**—Catalog, 8 pp. Contains photographs, features and applications of representative automatic pressure, temperature and level control valves. Atlas Valve Co, 280 South St, Newark 5, NJ.

(J-18) **Solenoid Valves**—Catalog, 4 pp. Description of 2-, and 3-way solenoid valves for use with air, oil, liquids and semi-corrosive media. Also presents various configurations, pressure ratings and price information. Valcor Engineering Corp, 365 Carnegie Ave, Kenilworth, NJ.

(J-19) **Metering Pumps**—Catalog, 34 pp. Gear and rotary pumps in corrosion resistant alloys. Sizes, performance data and other information given. ECO Engineering Co, 12 New York Ave, Newark 1, NJ.

(J-20) **Coolant Pumps**—Bulletin, 4 pp. Description, photographs and dimensions of immersed and flange mounted coolant pumps, also portable tank units. The Ruthman Machinery Co, 1809-23 Reading Rd, Cincinnati 2, Ohio.

(J-21) **Pneumatic Components**—Catalog, 56 pp. Dimensions and suggested applications of air cylinders, valves, work feeders, hammers, presses, vises and accessories. Mead Specialties Co, 4114 N Knox Ave, Chicago 41, Ill.

(J-22) **Valves**—Catalog, 8 pp. Describes construction and types of pneumatic and hydraulic control valves and actuators; shows various models with physical dimensions and other engineering information. Versa Products Co, Inc, 249 Scholes St, Brooklyn, NY.

(J-23) **Flexible Duct**—Catalog, 8 pp. Describes constructions available for air handling, dust and fume removal, materials handling; selector chart showing types for various applications. Flexible Tubing Corp, New Whitfield St, Guilford, Conn.

(J-24) **Air Control Valves**—Bulletin, 12 pp. Contains guide to air valve selection; discusses nomenclature; and lists directional control valves according to operating principle, capacity and type. Hannifin Co, Div of Parker-Hannifin Corp, 525-D South Wolf Rd, Des Plaines, Ill.

(J-25) **Gear Pumps**—Catalog, 56 pp. Presents specification sheets, formulas, dimension drawings, performance charts, mounting and plumbing data on line of gear pumps and directional control valves. Industrial Products Div, Cessna Aircraft Co, Hutchinson, Kan.

(J-26) **Air Valves**—Catalog, 26 pp. Describes butterfly air valves and actuators; electropneumatic poppet, pneumatic check, and drain valves for aircraft applications. Barber-Colman Co, Aircraft Controls Div, Rock St, Rockford, Ill.

(J-27) **Filters**—Bulletin, 4 pp. Describes oil and coolant filters, magnetic separators, clarifiers, conveyors, settling tanks. Indiana Commercial Filters Corp, Lebanon, Ind.

(J-28) **Pressure Control Valves**—Catalog, 12 pp. Describes operation, applications, and features hand, foot and mechanically operated models. Westinghouse Air Brake Co. Industrial Products Div, PO Box 36, Wilmerding, Penna.

(J-29) Hydraulic Pumps and Valves—Catalog, 20 pp. Specifications for motor pumps, directional and relief valves, as well as mounting data and ordering information. Webster Electric Co, 1900 Clark St, Racine, Wis.

(J-30) Solenoid Valves—Catalog, 114 pp. Includes engineering information, pipe sizes, pressures, nomographs, and others on various types of 2-, 3-, and 4-way solenoid valves. Automatic Switch Co, Florham Park, NJ.

(J-31) Metallic O-rings—Bulletin, 32 pp. Specifies temperature, pressure and dimensional limits of metallic o-rings. United Aircraft Products, Inc, Box 1035, Dayton, Ohio.

(J-32) Solenoid Valves—Catalog, 8 pp. For low temperature, high pressure applications. Fluids handled: air, nitrogen, oxygen, helium, hydrogen and other gases and liquids. Includes pipe sizes, pressures, pricing information. Automatic Switch Co, Florham Park, NJ.

(J-33) Hydraulic Cylinders—Catalog, 8 pp. Describes construction and gives dimensions, engineering and ordering information. Ortman-Miller Machine Co, Inc, 19-143rd St, Hammond, Ind.

(J-34) Pneumatic Products—Catalog, 24 pp. Product information and engineering data covering filter-regulator-lubricator units for machine tools. Watts Regulator Co, Industrial Div, 10 Embankment St, Lawrence, Mass.

(J-35) Strainers and Blinds—Catalog, 8 pp. Description and engineering data pertaining to pipe line flow protection and control. The Mack Iron Works Co, Sandusky, Ohio.

(J-36) Blower Wheel—Catalog, 50 pp. Describes line of centrifugal wheels for the air moving industry. Performance graphs and specifications. The Torrington Mfg Co, Torrington, Conn.

(J-37) Valves—Catalog, 20 pp. Control valves, manual and solenoid operated for air oil and water service—rated pressure 250 psi to 10,000 psi. Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58, Calif.

(J-38) Hydraulic Servomechanism—Bulletin, 4 pp. Gives specifications, sizes and general description of series unit. Also shown—gear pump which is matched to supply the servo. Behlen Mfg Co, Inc, Industrial Site, Columbus, Nebr.

(J-39) Hose and Hose Assemblies—Catalog, 12 pp. Chemically inert, high-temperature resistant flexible and flanged hose assembly tabulations. Also covers super solvent and hot finishing spray hoses with JIC adapters; also, charts and recommended applications. Resistoflex Corp, Roseland, NJ.

(J-40) High-pressure Valves—Catalog, 100 pp. High-pressure pneumatic regulators and hydraulic control valves. Specifications, operation and design curves are included. The Marotta Valve Corp, Boonton Ave, Boonton, NJ.

(J-41) Teflon-lined Pipe and Fittings—Bulletin, 4 pp. Tabulation of pipe sizes, corresponding fittings in ells, tees, reducing flanges, spacers and others with assembly instructions and list of chemicals to which the piping is chemically inert. Resistoflex Corp, Roseland, NJ.

(J-42) Control Valves—Bulletin, 4 pp. Describes valves for high pressure hydraulics, air, steam, hot or cold water, and gases. The Sinclair-Collins Valve Co, Div of International Basic Economy Corp, 454 Morgan Ave, Akron, Ohio.

(J-43) Control Valves—Bulletin, 16 pp. Describes 2-, 3-, and 4-way manual, remote, and electrically operated air and hydraulic valves. Valvair Corp, Div of International Basic Economy Corp, 454 Morgan Ave, Akron, Ohio.

(J-44) Pumps—Catalog, 20 pp. Describes construction, performance, applications and limitations, of roller, rubber impeller and piston type pumps. Instruction for users and illustrated parts sheets. Hypro Engineering, Inc, 700-39th Ave NE, Minneapolis 21, Minn.

(J-45) Stainless Steel Hose—Bulletin, 4 pp. Describes flexible metal hose for loading and conveying corrosive chemicals, superheated steam, gas, oils, and other high temperature applications. Lists sizes, maximum working pressures, bursting pressures, standard fittings and flanges. Also, formula to determine required hose length. Allied Metal Hose Co, Long Island City 1, NY.

(J-46) Valves—Brochure, 4 pp. Gives operating pressures, dimensions and service recommendations for line of check, relief, shutoff, and plug valves. Circle Seal Products Co, Inc, 2181 E Foothill Blvd, Pasadena, Calif.

(J-47) Valves—Catalog, 16 pp. Describes types and sizes for handling any known chemicals or abrasive materials. Gives engineering and capacity information as well as description of operation. RKL Valve & Mfg Co, Rt 38 & Rudderow Ave, Maple Shade, NJ.

(J-48) Automatic Valves—Catalog, 128 pp. Complete data on special automatic valves for water, air, steam, oil, and others. Capacity charts, selection tables, spring ranges and temperature limitations. A W Cash Valve Mfg Corp, 666 E Wabash Ave, Decatur, Ill.

(J-49) Hydraulic Jacks—Catalog, 16 pp. Describes applications, capacities and other specifications, as well as engineering information and product knowledge on hand and service jacks, one-end lifts, wheel dollies, transmission jacks and stands. Milwaukee Hydraulic Products Corp, 800 South 108th St, Milwaukee, Wis.

(J-50) Rotary Pumps—Catalog, 8 pp. Specifications, illustrations and descriptions of general purpose and heavy-duty positive displacement pumps in sizes from ¾ to 1050 gpm. Pressures to 200 psi. Viking Pump Co, Cedar Falls, Iowa.

(J-51) Rotary Pumps—Bulletin, 8 pp. Describes rotary pumps using a sliding vane, construction and application data; ranging in capacities from 10 to 1500 gpm. Also covers hand pumps, rotary and piston type for barrel use. Blackmer Pump Co, 1809 Century Ave S W, Grand Rapids, Mich.

(J-52) Controls and Components—Bulletin, 6 pp. Data sheets describing fluid system controls and components. Lists specifications, features, applications. Waldorf Fluid Systems, Div of F C Huyck & Sons, Wolf Hill Rd, Huntington Sta, LI, NY.

(J-53) Oil Filters—Catalog, 12 pp. Engineering data and dimensional charts on sump and line type filters for hydraulic oils, coolants and lubricants. Marvel Engineering Co, 7227 N Hamlin Ave, Chicago 45, Ill.

(J-54) Screw Pumps—Bulletin, 6 pp. Intended for use with oils and other noncorrosive liquids of wide viscosity range at discharge pressures up to 350 psi and capacities up to 550 gpm. Selection nomograph, dimensions, sectional drawings, and details of design and construction are provided. Warren Pumps, Inc, Warren, Mass.

(J-55) Spray Nozzles—Catalog, 48 pp. Contains information on spray nozzles for all types of chemical and industrial spray applications: pipe sizes, external dimensions, orifice diameters, capacities and spray angles. Spraying Systems Co, 3201 W Randolph, Bellwood, Ill.

(J-56) Hydraulic Cylinders—Catalog, 35 pp. Specifications of all types of hydraulic cylinders as well as engineering data. Cross Mfg Co, Lewis, Kansas.

(J-57) Gear Pump—Bulletin, 15 pp Pump specifications, dimensional data, performance curves, hydraulic engineering data sheets. Northern Ordnance Inc, Subsidiary of Northern Pump Co Columbia Heights P O, Minneapolis 21, Minn.

(J-58) Rotary Pumps—Catalog 12 pp. Describes and illustrates a line of positive displacement, external gear, rotary pumps; sizes from 0.6 to 600 gpm, pressures to 1000 psi. Roper Hydraulics, Inc, 405 Blackhawk Park Ave, Rockford, Ill.

(J-59) Air Control Valves—Catalog, 48 pp. Air control valves for all types of pneumatic applications. Also illustrates the 400 and 600 rfl unit. Logansport Machine Co, Inc, Logansport, Ind.

(J-60) Metal Packing—Brochure, 23 pp. Describes lubrication, sealing theory and mounting of free- and nonfloating packings, metal scraper rings, and others. Pressure ranges, material specifications, lubrication lines, and field measurement data are given. The Garlock Packing Co, 402 Main St, Palymyra, NY.

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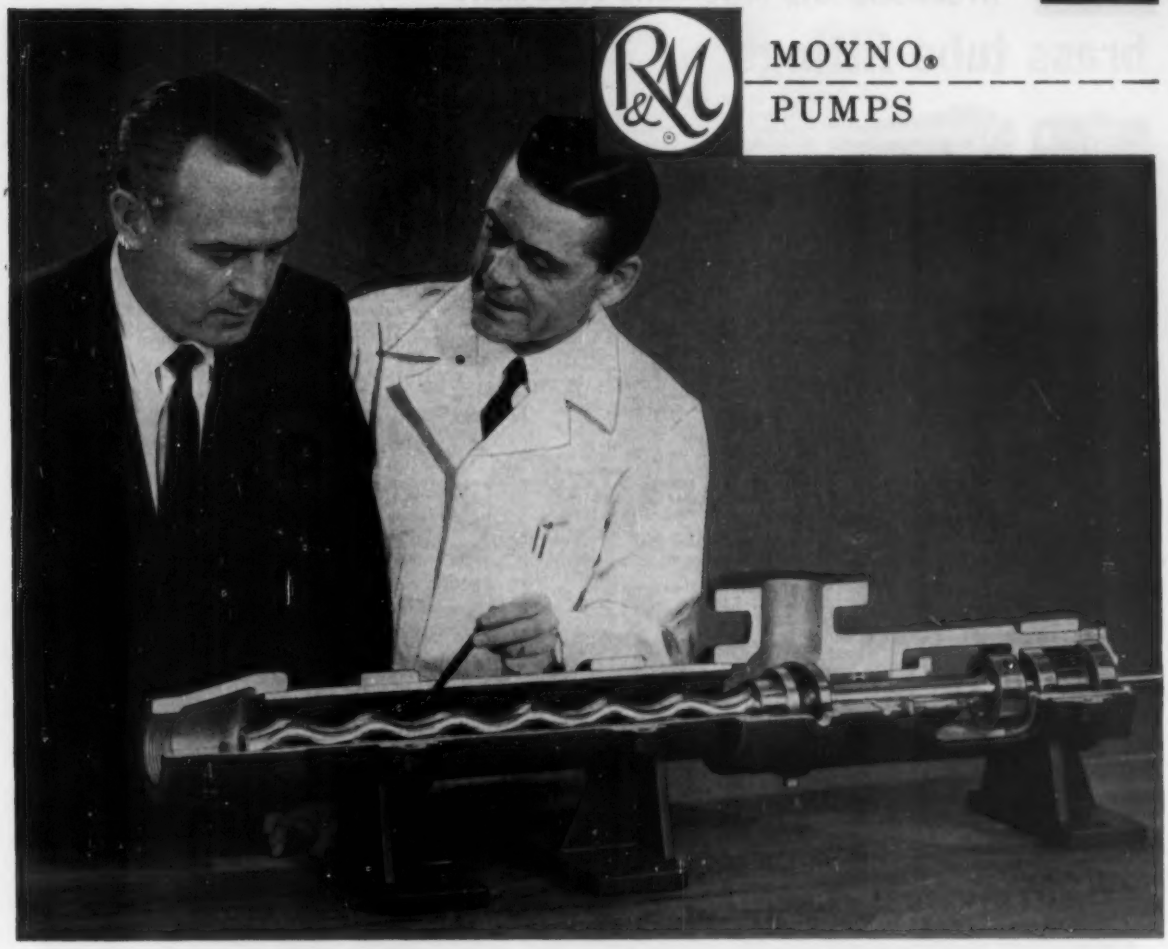

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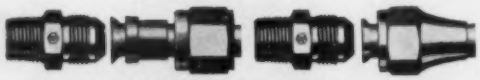

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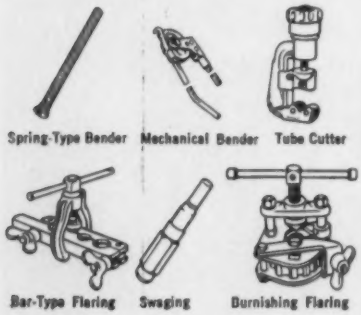

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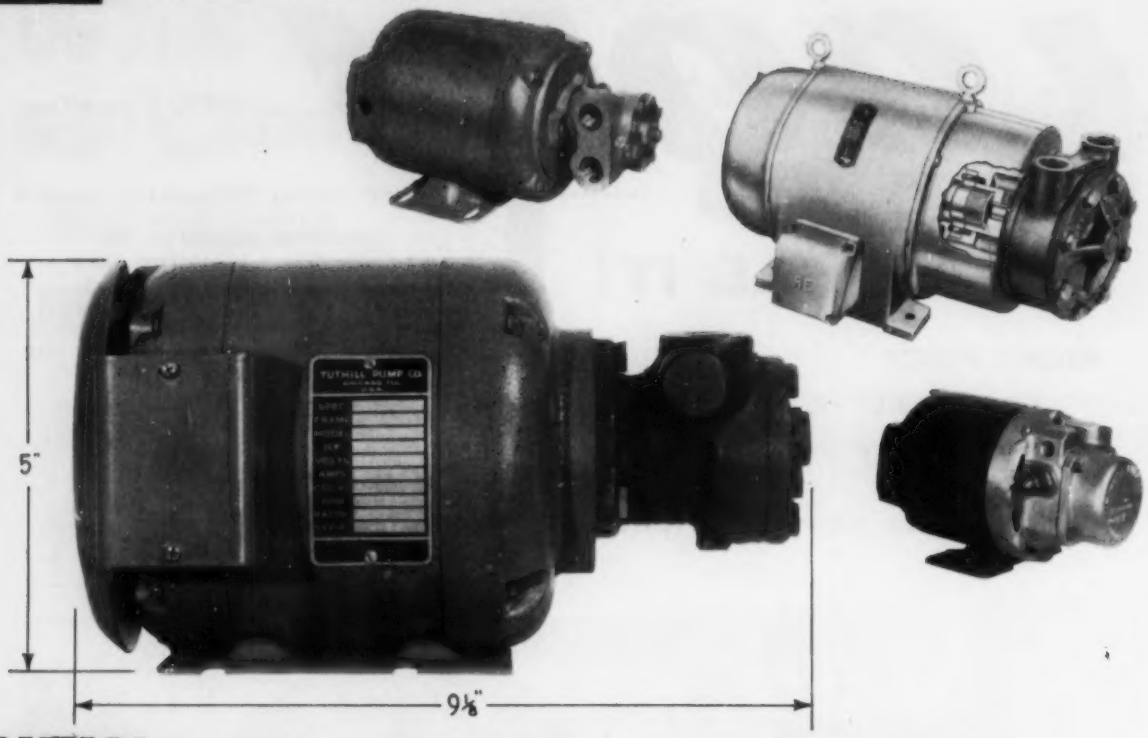

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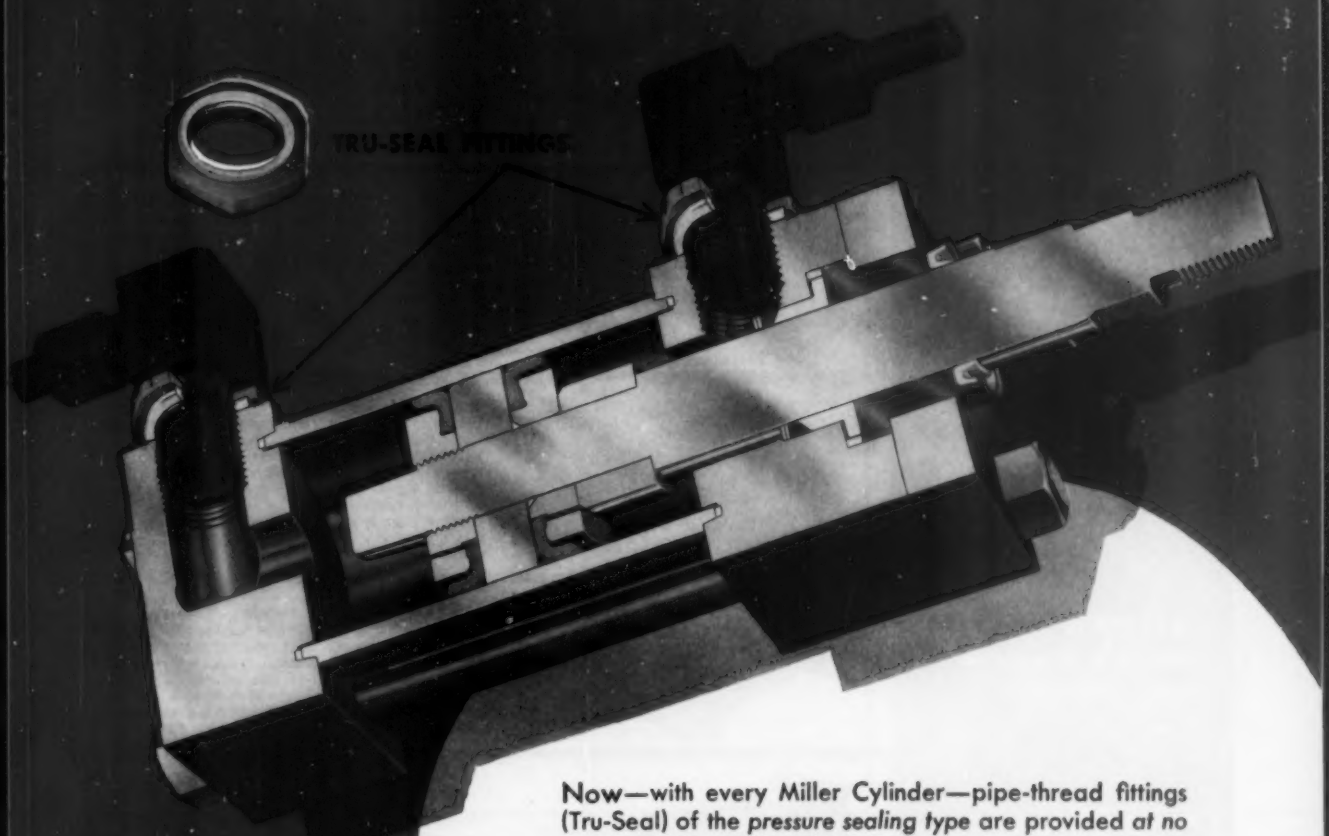

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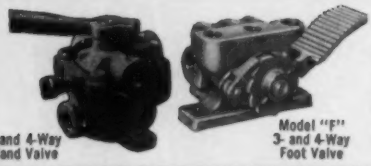
Rotating Disc
VALVES



3-and 4-Way Hand Valve

Model "F" 3- and 4-Way Foot Valve

2-, 3-, and 4-way, are used for hand or foot control of cylinders to 250 p.s.i., air or oil. Rotating disc covers metal-to-metal seat, shielding it from pressure flow or exhaust blast. This simple, rugged, packless construction (only 2 moving parts) has never been equalled for durability. Large variety of operating cycles obtainable. Model "F" shown provides unique 4-way cycle: reverses flow through valve on each pedal downstroke only.

NOPAK-MATIC
Poppet-Type
Pilot-Operated
VALVES

SERIES 420 4-Way

SERIES 310 2- or 3-Way

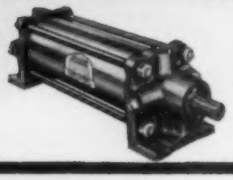
These fast acting, high volume air valves available in ¼" to 1¼" pipe sizes with master (air piloted), single or double solenoid. Mounting choice: side or bottom ported subplates or manifolds. No valve seats or piston bores machined into valve body. Removing end cover plates gives easy access to air actuated (no springs) piston poppets housed within removable, interchangeable cartridges. No disturbance of piping, wiring or mounting. 100% J.I.C. Standard valves operate as low as 10 p.s.i. Easily modified for vacuum operation.

NOPAK FLOTROL®
Speed Control
VALVES

FLOTROL Model 20V

Variable Orifice Type capitalizing on the advantages of protected seat, pressure sealing and precision throttling inherent in rotary valve design — this flow control valve incorporates a bronze disc with crescent shaped port rotating over an aluminum body seat to which it is precision lapped. Desired orifice opening is obtained by external rotation of adjusting sleeve, subsequently locked in place by a set screw; 180 degree rotation full open to close. "In line" flow construction results in maximum volume, no restrictions through adjusting needles.

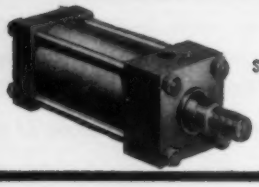
NOPAK
Class 1, 2 and M*
CYLINDERS



Model A Class 1 & 2 NOPAK Cylinder

Brass Tubing — Tie-Rod Cylinders with semi-steel cast heads for air, oil, or water service. Diameters from 1½" to 16", suitable for 250 p.s.i. Large selection from Shelf-Stock. Class 2 Cylinders have cylinder wall recessed into cylinder head, sealed by fibre gaskets. Class 2 recommended for air, oil, or water at pressures to 500 p.s.i. During the past 20 years they have earned a reputation as "The most cylinder for the least money."

NOPAK
Class 3 Square
Head CYLINDERS



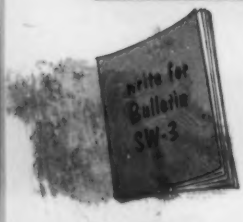
Square Head Cylinder

For Hydraulic service at pressures to 3000 p.s.i. Compact steel plate, square head, and tie-rod construction. Honed steel tubing. Heads adjustable cushioned or non-cushioned. 18 standard mountings. Interchangeable with other well-known square head hydraulic cylinders.

NOPAK
Class 4 Hydraulic
CYLINDERS

Model E Class 4 cylinder

These high-pressure hydraulic cylinders are fabricated from heavy, honed steel tubing with lock-ring flange construction which permits head rotation for most convenient mounting. No tie-rods! Built for hydraulic service to 4000 p.s.i. Choice of cushioned or non-cushioned heads; 5 standard mounting styles.



Bulletin SW-3 gives you a condensed summary of the Complete NOPAK Line. If you do not have a copy, write for Bulletin SW-3 — and address of nearest NOPAK representative — on your company letterhead, please.

* Class M Cylinders (Mill Type) have welded flange construction with honed steel tubing. No tie-rods. For all types of Heavy-Duty service at air or hydraulic pressures up to 750 p.s.i.

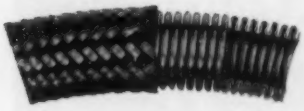
NOPAK VALVES and CYLINDERS

GALLAND-HENNING NOPAK DIVISION
2750 S. 31st STREET • MILWAUKEE 46, WIS.

A9-847

Whatever your problem in flexible hose connections,

call the Man from Anaconda Metal Hose



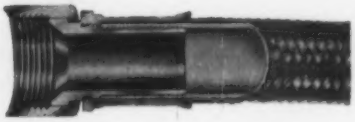
Seamless: Of tin bronze (98¾% copper, 1¼% tin)—also corrugated stainless steel—in sizes ⅛" through 4" I.D. For conveying fluids, chemicals, etc., under conditions of flexure or vibration and to allow for misalignment. Reusable (mechanical type), soldered or welded fittings.

Stripwound: Constructed from brass, bronze, aluminum, galvanized or stainless steel. Sizes ½" through 8" I.D. A rugged type of hose for general service as steam, oil, water, particularly where the hose is handled manually. Fittings: soldered or heat-proof (packed-on).

Type UI: Interlocked unpacked hose in galvanized steel, stainless steel, aluminum, etc. Sizes through 8" I.D. For ventilating ducts, dust collection, engine exhausts, exhausts at grinding machines, bottle chutes, drain lines, protective casing for flexible hose assemblies.

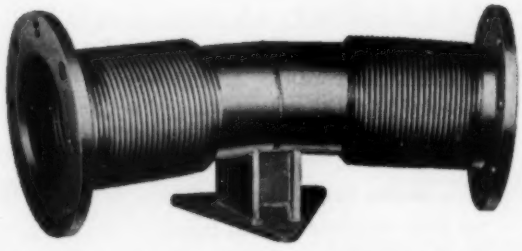
Diesel: Heavy-duty steel exhaust and air intake hose. Sizes 2" through 16" I.D. Designed for rugged, heavy-duty use. Helical corrugations with open or closed pitch. Also in stainless steel (type Y-21) for corrosive applications.

Flexpipe: Takes up travel in piping, connects misaligned ports, dampens noise and vibration in piping. Standard sizes and lengths. Available in bronze, stainless steel, steel; in sizes ¼" through 16" I.D. with NPT fittings, flanges or welding nipples.



Teflon* Anaconda flexible connectors of Teflon with stainless steel wire braid for use with pipe sizes from ⅛" through 1¼". Available in a wide variety of standard hose assemblies complete with fittings.

*Teflon is a DuPont trademark for its fluorocarbon resins.



AX Tubing: Large diameter tubing for big, tough jobs. Available in Type 321 Stainless Steel, and other metals and alloys. Sizes from 4½" through 14" I.D. Designed to handle axial and lateral movement—while conveying large volumes of liquids or gases—for bulkhead seals, etc.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on special flexible connectors and hose to meet new problems. Having broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon, they can save you considerable time and money in designing the flexible connector best suited for any of your jobs.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities—see listing "Metal Hose" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn.

ANACONDA® METAL HOSE

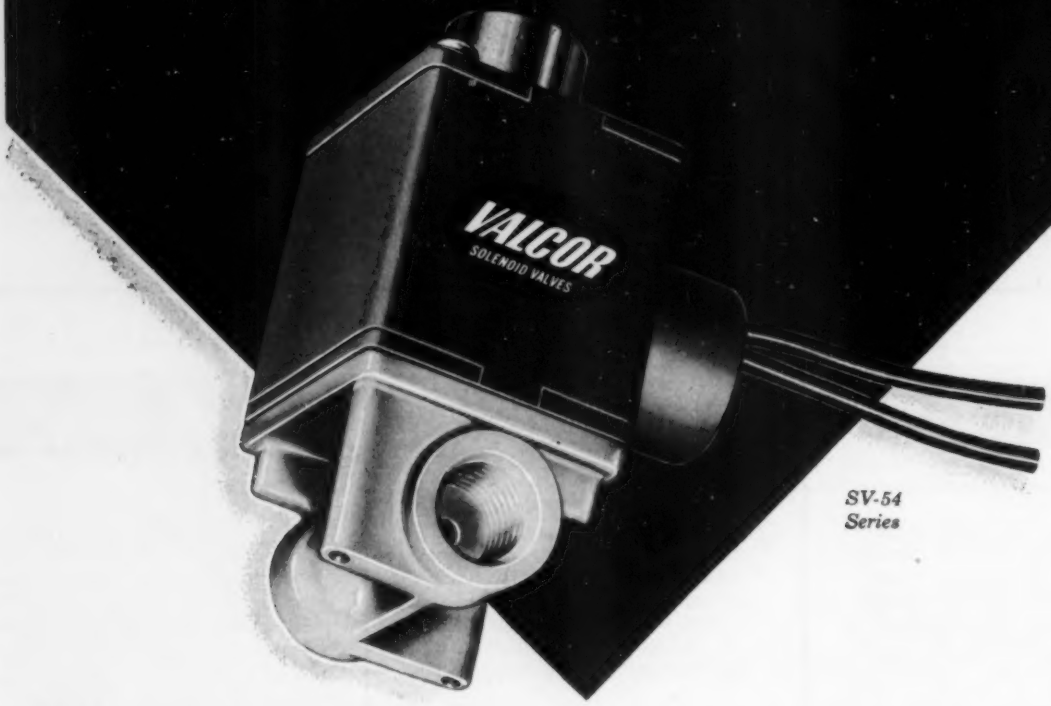
WRITE 553 ON READER SERVICE CARD

New 3-Way Nylon-Body Solenoid Valve...

List Priced as Low as $10.75...

(Quantity Discounts Available)

Outlasts, Outperforms Steel!



SV-54 Series

VALCOR'S new 3-way Nylon solenoid valve, SV-54 Series, outlasts and outperforms steel, yet is list priced as low as $10.75! In general purpose and O.E.M. installations, where millions of operating cycles are essential, this new Valcor valve not only works best but costs less.

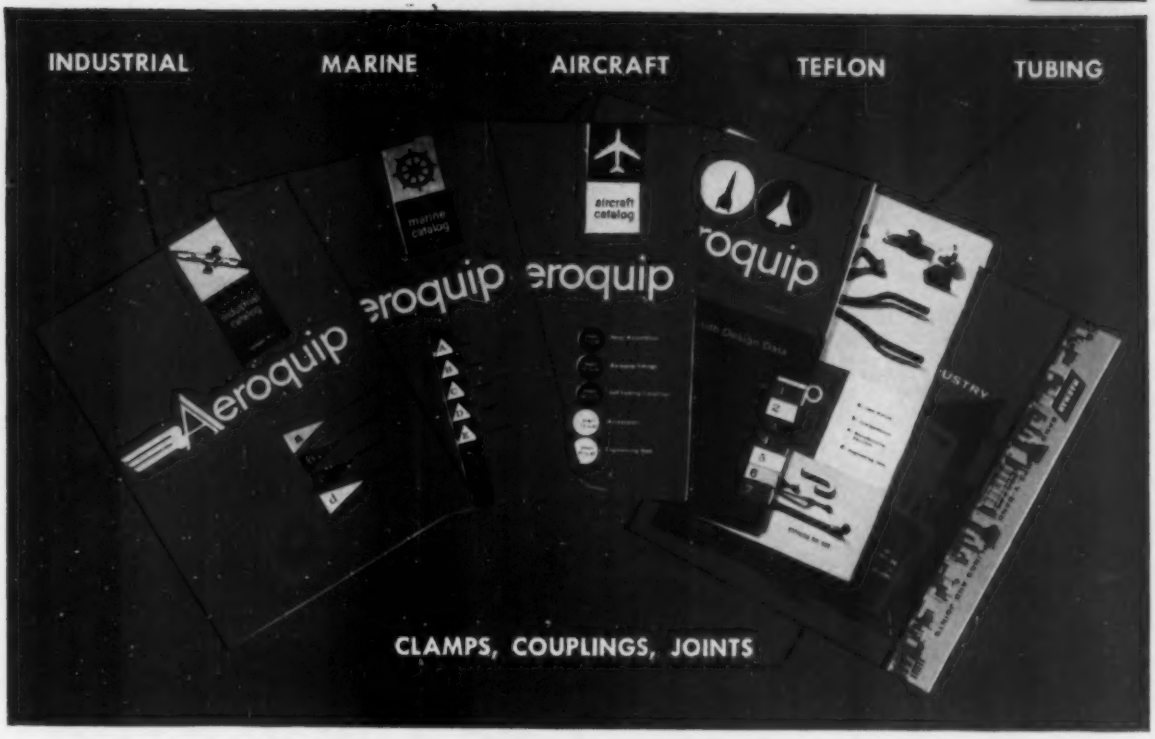
Its nylon seat outlasts steel... its port threads outlast steel... pound for pound it's *3 times stronger than steel.* Dry seal threads, no compound is needed—and they won't loosen even under severe vibration. Nylon is non-corrosive so you have no atmospheric problems. And the stainless plunger is a reliable workhorse for millions of cycles. Bubble tight sealing. Available in normally open, normally closed and "directional control" configurations in all normal AC and DC voltages... 1½" square x 3" long (valve illustrated).

Write today for complete technical data on this shock-resistant, pressure-proof valve—the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

VALCOR SOLENOID VALVES

VALCOR ENGINEERING CORP.

5375 Carnegie Avenue, Kenilworth, New Jersey

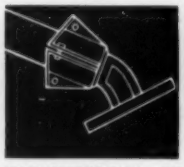


Aeroquip Catalogs Aid Fluid System Designers

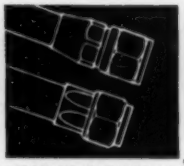
Here is a total of 356 pages packed with information valuable to designers of fluid systems. Each of these catalogs is filled with complete product specifications and helpful engineering data for a variety of industries and products.

These Aeroquip catalogs are revised regularly to assure that all information is current. If you do not have the catalogs listed below, order your copy, or copies, today. Fill in and mail the coupon below.

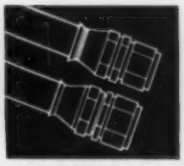
INDUSTRIAL CATALOG No. 203 contains full product and engineering data on hose, fittings and couplings for general use. [illegible] pages.



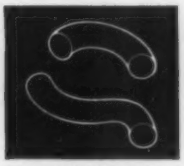
MARINE CATALOG No. 303 features flexible piping for all marine use, complete with special fittings, engineering data. 54 pages.



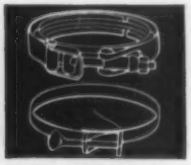
AIRCRAFT CATALOG No. 103 details standard and special aircraft hose, fittings and couplings. 88 pages.



HOSE OF TEFLON CATALOG No. 104 lists complete range of Aeroquip Hose Lines of Teflon with patented* **"super gem"** Fittings. 68 pages.



TUBE FORMING CATALOG No. 500 follows tube forming examples with facilities and engineering data. 42 pages.



MARMAN CATALOG of industrial clamps, couplings and joints for tubing, piping and ducting. 36 pages.

"super gem" is an Aeroquip Trademark.
Teflon is DuPont's tradename for its tetrafluoroethylene resin.
*U.S. Patent Nos. 2,833,567 and 2,731,279.

General Logistics catalog of cargo tie-down and load control equipment for aircraft, trucks and materials handling. 40 pages.

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Aeroquip Corporation, Jackson, Michigan. Please send me the up-to-date Aeroquip catalogs checked below. PEDD-59

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- ☐ MARINE CATALOG NO. 303
- ☐ AIRCRAFT CATALOG NO. 103
- ☐ HOSE OF TEFLON CATALOG NO. 104
- ☐ TUBE FORMING CATALOG NO. 500
- ☐ MARMAN INDUSTRIAL CATALOG
- ☐ GENERAL LOGISTICS CATALOG

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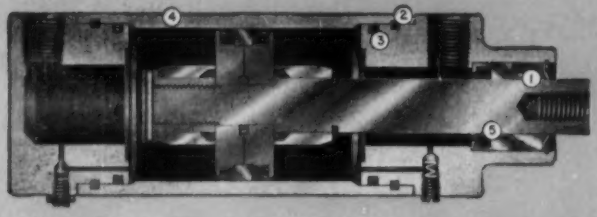

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3.—Leakproof "O" Ring seal between head and wall.

4.—Precision honed heavy wall tubing—6 to 1 safety factor.

5.—Spring loaded "V" packing on rod end gland.

Solve your **FLUID POWER** problems with lightweight, more compact, dependable fluid power components!

. . . IMMEDIATE DELIVERY, TOO!

COMPLETE DESIGN FILE

All specifications and ordering information on the complete Carter Designer's Line. Everything you need for designing highest quality fluid power components into your product.

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A new low-cost, all-steel, all purpose cylinder. All the dependability of the standard Carter line. Bulletin CT-1000-B.

AIR CYLINDERS
Standard sizes 1½" thru 8"; stroke lengths to 18 feet; all mounting styles. All essential designing and ordering information. Bulletin 100-B.

UNITIZED AIR CYLINDERS
Carter unitized cylinder with built-in valve! Solenoid, air-limit or remote poppet control. Bulletin 125-A.

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For ovens, furnaces, etc. Range: —20° to 500°F. Special high temperature packings and lubrication. All sizes, strokes. Bulletin HT-500.

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Heavy duty hydraulic unit. Pressures to 1500 psi. Standard sizes. 1½" thru 8". Strokes to 18 ft. Complete specifications. Bulletin 1500-B.

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Unlimited rotary motions. Valve operation, indexing, actuating of all kinds. Powerful, rugged. Drastically reduces cost. Bulletin RA-500.

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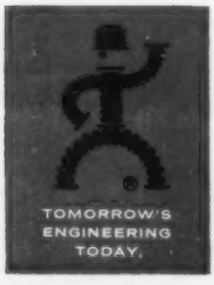

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The New

interchangeable with all standard JIC cylinders

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

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9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

T-J TOMKINS-JOHNSON

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WRITE 559 ON READER SERVICE CARD→

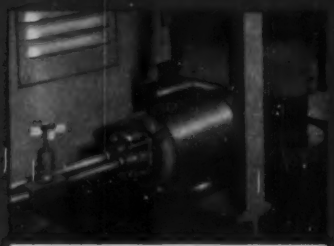
ROPER CUSTOM PUMPS

Practically a complete hydraulic system in itself, this Roper custom job is a unit for a platform leveler. The design includes pump, check valve, relief valve, and connection for solenoid lowering valve as well as cylinder and tank connections. This is but one of the many examples of custom work Roper does to match its customers needs and/or specifications. Our staff is ready to work with you at any time. Roper Standard Pumps are shown below.

FOR DEPENDABLE PUMPING

Specify

ROPER

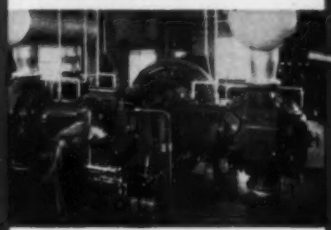


Typical use of Series T on test stand for scavenging and transfer operation.

SERIES T

COMPACT, INTEGRAL PUMP & MOTOR UNITS

"All-in-one" units with pump serving as end bell of motor. Require minimum space and are easily installed . . . no coupling required . . . mount in any position. Choice of 192 models. Each unit is approximately same size as NEMA motor of HP required for driving. Open drip proof or totally enclosed motors; single or three phase as required. .3 to 55 GPM at rated maximum pressure.



Series F used as before and after pump to supply oil to bearing surfaces of compressor.

SERIES F

FEATURE 4-PORT DESIGN

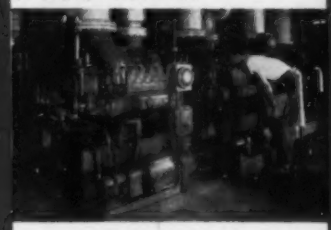
Feature helical steel pumping gears, hardened steel shafts, bronze flange-type bearings. Have 4-port design with 8 optional piping arrangements (4 for CW and 4 for CCW rotation) to provide installation flexibility. Supplied with or without built-in relief valve in either mechanical seal or packed box construction. 1 to 300 GPM, to 300 PSI.

Series H used in fuel heating system of 1000 HP pumping rig in Saudi Arabia.

SERIES H

FOR HIGH PRESSURE APPLICATIONS

Designed to operate at direct motor speeds. Widely used for all types of hydraulic mechanisms where high pressures are required. Hardened steel spur gears for maximum efficiency, and heavy duty roller bearings and bronze wear plates for long life service. Available with mechanical seal or packed box . . . external relief valve recommended for all installations. 5 to 75 GPM, to 1000 PSI.



Series K furnishes pressure lubrication to these continuous duty compressors.

SERIES K

FEATURES PATENTED VENTURI PRINCIPLE

Extremely compact in all sizes. Helical pumping gears are hardened steel, with steel shafts and bronze bearings. Sizes 10 through 50 GPM have *patented venturi suction and discharge principle* for smooth flow and quiet operation. With or without built-in relief valve; packed box or mechanical seal construction. ¾ to 50 GPM, to 150 PSI.

Battery of Series 3600 pumps used in packaging plant of large oil producer and marketer.

3600 SERIES

FOR GENERAL PURPOSE PUMPING

Designed to handle thick or thin liquids at slow speeds. Operate smoothly and efficiently in either direction, and feature hardened iron pumping gears, hardened steel shafts, and heavy duty bronze sleeve bearings. Furnished with mechanical seal or packed box. Available on steel bedplate, with or without motor, and gear reduction. 40 to 300 GPM, to 100 PSI.

ROPER

ROTARY PUMPS

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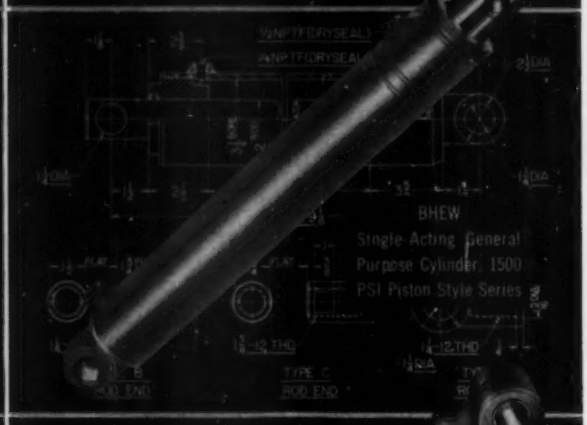
Rockford, Ill.

J — HYDRAULIC AND PNEUMATIC EQUIPMENT

BHEW HYDRAULIC CYLINDERS

• BASIC DESIGNS • SPECIFIC ADAPTATIONS • SUPERIOR QUALITY • APPLICATION ENGINEERING



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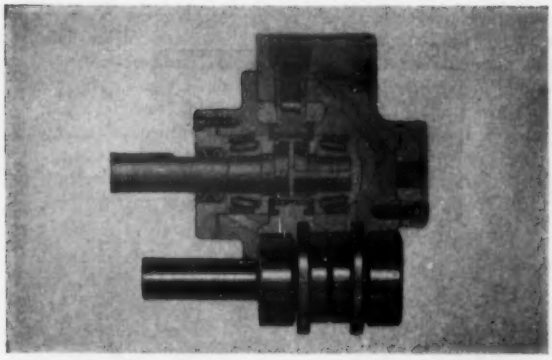
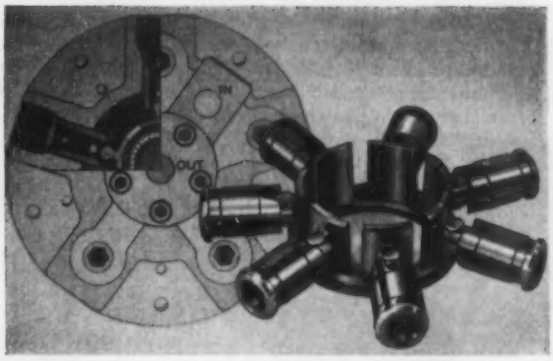
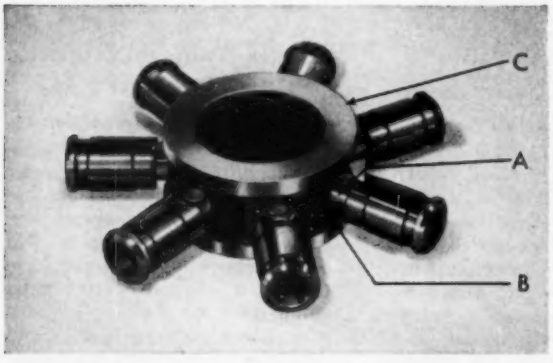
Only the AE Hydramite gives you these 4 key benefits



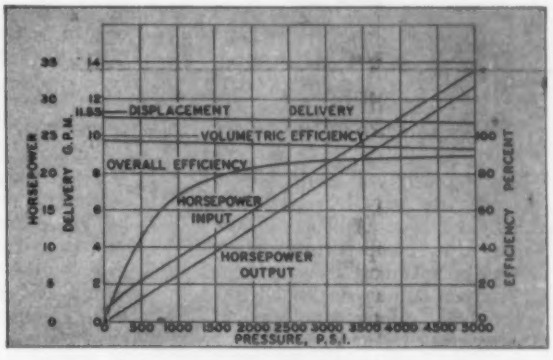
1. Tapered roller bearings. Two high capacity, heavy duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment . . . handle heavier unbalanced loads . . . and last longer. The pump casing is ported so that the pumping action of tapered bearings will provide better lubrication.



2. Curved slippers riding on the outer race of the cam shaft needle bearing minimizes scrubbing action between these parts. They also distribute thrust loads of the plungers and reduce unit stresses to the point where maintenance will never be required at what is a critical wear point in most hydraulic pumps.



3. Positive pumping action. The Hydramite has no cam follower springs to fail. Plungers (A) are connected to curved slippers (B) which are held against the outer race of cam shaft needle bearing by two plunger return rings (C). As the shaft revolves, each plunger is pushed outward in succession and then pulled back by the return rings.



4. High efficiency. With a Hydramite you get an overall efficiency of 85%. Shown above is typical 10 gpm pump curve. Its flat overall high efficiency has little variation between 1,500 and 5,000 psi. What's more, with a Hydramite you get positive suction. There is no need for supercharging equipment which reduces system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 30 gpm at 5,000 psi and 70 to 85 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F.

Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles. Write or call American Engineering Company, Dept. P-148, Philadelphia 37, Pa. Phone: CUmberland 9-3800.

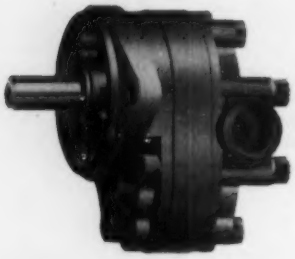
AMERICAN ENGINEERING COMPANY

Hele-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra Grate, Perfect Spread and Taylor Stokers.

Mobile Hydraulics from Cessna

Pumps, Valves and Cylinders

Specialization in mobile hydraulics has paid off handsomely for Cessna Industrial Products Division and its customers. Concentrating in this field, its Engineering Department has developed product designs that establish advanced standards of performance and reliability. Skilled specialists in the Hutchinson plant produce finished articles from these designs that pass the most rigorous tests of actual service. The plant is fully equipped to handle every processing and machining operation involved in production of precision hydraulic components. It is equipped for induction heat treating, induction brazing, automatic submerged arc welding, chromium plating, Kolening and many other processes. The machine shop and associated departments are among the most complete and modern in Mid-America. Many of the operators have worked in the plant ever since it was built in 1942. Here are people who take pride in their work. Users of Cessna hydraulic components include most of the major farm equipment manufacturers in the United States and Canada, and many other leading makers of hydraulic-equipped machinery. From Cessna's concentration in this field, they have gained an experienced source of engineering collaboration, and a dependable point of supply for the elements of their hydraulic systems.

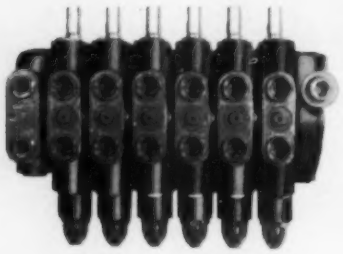


Cessna Spur Gear Pumps

Normal Ranges 5.4 to 45 GPM

Single, Double, Special Models

Cessna pumps are compact, light in weight and easy to engineer into limited spaces. A choice of sizes, plus many pump port adapter options permits most needs to be met from cost-cutting stock models. A new design principle provides maximum efficiency and long life from the simple, low cost, time-tested spur gear action. Gear end clearance is kept to a minimum by a flexible wear plate which is pushed against the gear ends by controlled fluid pressure. This provides a constant take up of gear end clearances in spite of wear, adding many hours to the useful life of the pump. Stock and special designs cover the full range of today's mobile hydraulic systems. Cessna Spur Gear Pumps have passed the most severe tests of hard service. They will supply dependable hydraulic power for your product – and help to keep your customers happy.

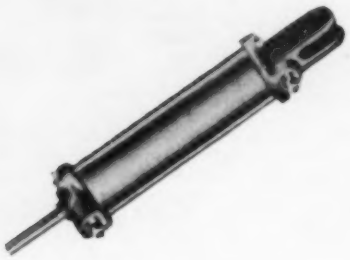


Cessna Control Valves

2,000 PSI, 15 to 30 GPM Range

Single, Stacked, Other Types

Whatever kind of control, relief, steering or unloading valve you need you can get from Cessna – very likely from stock models that give you the advantages of custom design at "off-the-shelf" cost savings. Consider the stacked valve shown above – using any number of working sections in any order, plus the ability to add more sections in the field for optional equipment. You can call for almost any lineup of operating methods and features known to valve design. Just name your need. You will get it from Cessna – and it will be the very best of its kind.



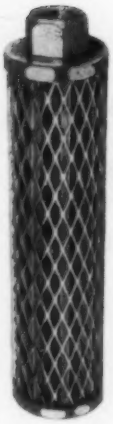
Cessna Hydraulic Cylinders

1,000 to 3,000 PSI Range

Single and Double Action

It is doubtful if you'll find a greater variety of styles and sizes of hydraulic cylinders anywhere than those produced by Cessna. No matter what application you have in mind, it is virtually certain to be within the scope of Cessna's experience. A vast majority of single and double-action cylinders used by the farm equipment industry are of Cessna manufacturer. Power steering is another Cessna specialty. In all applications, Cessna cylinders have performed well. Special care on rod and barrel finishes prevents rust, reduces wear, protects seals. Again, Cessna is your best choice.

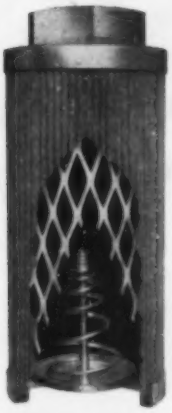
Cessna AIRCRAFT COMPANY
INDUSTRIAL PRODUCTS DIVISION
HUTCHINSON, KANSAS



Tandem Synclinal SUMP TYPE

CAPACITIES: 10—16—20—40—60—100—150 and 200 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3".
CONNECTIONS: Coupling—Male Nipple.
BY-PASS VALVE: Not available.

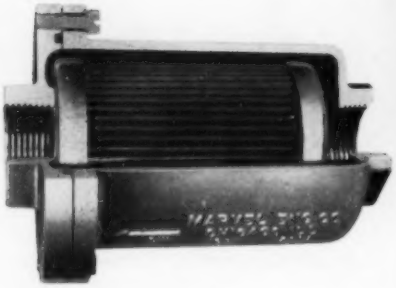
For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.



Bonded SUMP TYPE

CAPACITIES: 10—20—30—50 and 75 G.P.M.
PIPE SIZES: 1"—1¼"—1½"—2"—and 2½".
CONNECTIONS: Coupling—"O" Ring—Male Nipple.
BY-PASS VALVE: Available with or without By-Pass Valve.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants and all types of Fire-resistant Hydraulic Fluids.



IN-LINE FILTER

CAPACITIES: Up to 60 G.P.M.
PIPE SIZES: ¾"—1"—1¼" and 1½" (at both inlet and outlet).
BY-PASS VALVE: Available with or without By-Pass Valve.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants and all types of Fire-resistant Hydraulic Fluids.

MARVEL
SYNCLINAL FILTERS

FOR DEPENDABLE PROTECTION on all Hydraulic and other low pressure circulating systems

MARVEL FILTERS are designed to give more ACTIVE filtering area—MORE dependable protection—MORE productive operation before filter cleaning is necessary. *They meet J. I. C. Standards.*

FILTERING MEDIA in all Marvel Filters is Monel wire cloth and available in mesh sizes of 30-40-50-60-80-100-150 and 200 to meet your degree of filtration requirement.

EASY TO CLEAN—All Marvel Filters are easy to clean. Line type units operate in any position and may be serviced without disturbing pipe connections.

OVER 900 Original Equipment Manufacturers install Marvel Filters as Standard Equipment.

IMMEDIATE DELIVERY

For further information on a specific type or size filter—Write—wire or phone

MARVEL ENGINEERING COMPANY
7227 N. Hamlin Ave., Chicago 45, Illinois • Phone: JUniper 8-6023

Synclinal SUMP TYPE

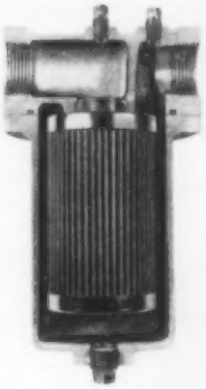
CAPACITIES: 5—8—10—20—30—50—75 and 100 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3".
CONNECTIONS: Coupling—Male Nipple.
BY-PASS VALVE: Not Available.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.

Synclinal LINE TYPE

CAPACITIES: 5—8—10—20—30—50—75 and 100 G.P.M.
PIPE SIZES: ¾"—1"—1¼"—1½"—2"—2½" and 3".
BY-PASS VALVE: Not available.
OPERATING PRESSURES: Up to 80 p.s.i.

For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids and Water.



Bonded LINE TYPE

CAPACITIES: 10—20—30—50 and 75 G.P.M.
PIPE SIZES: 1"—1¼"—1½"—2" and 2½".
BY-PASS VALVE: Available with or without.
OPERATING PRESSURE: Up to 250 p.s.i.
OPERATING TEMPERATURES up to 300° F.

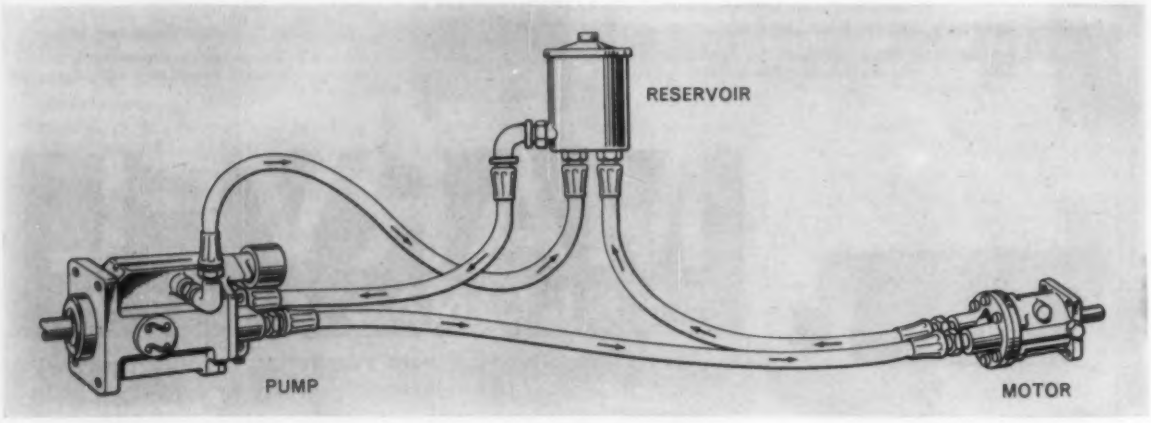
For use with regular petroleum base Hydraulic Oils, Coolants, Lubricants, all types of Fire-resistant Hydraulic Fluids.

WRITE 563 ON READER SERVICE CARD 563

Creative hydraulics by Sundstrand

Variable input—constant output speed transmissions designed for mobile equipment

Compact, lightweight, highly efficient hydrostatic transmissions develop up to 9 hp



32 PV Variable Displacement Pump

Reservoir 1½-Quart Capacity

7MC Fixed Displacement Motor

Here's a new idea in boosting efficiency of constant output speed auxiliary operations on mobile equipment. Compact, high-efficiency hydrostatic transmissions designed to use low-cost piston-type pumps and motors are being introduced in six standard sizes by Sundstrand—a company with more than 10 years' experience in constant speed drives.

Principal components of the Sundstrand hydrostatic transmission as shown at the left are: (1) Variable displacement axial piston pump, (2) a fixed displacement axial piston motor, and (3) a small (1½-quart) reservoir. Output horsepower depends on input speed range (see table at right).

Motor speed remains constant within ± 5% despite variations in pump input speed because of the unique control. The pump continually measures its own output and makes adjustments automatically in order to deliver a constant flow of oil.

By adding a small independent manual control to the circuit, pump delivery may be regulated to vary output speed of the motor from zero to maximum RPM. Constant motor output speed is maintained at any particular valve setting.

System is unusually compact and light in weight. There's no spilling of oil over a relief valve or bypassing of oil under pressure as pump delivers only the amount of oil needed. High efficiency is obtained —therefore there is no problem of heat dissipation.

Typical Hydrostatic Transmissions

OUTPUT H.P.	PUMP INPUT SPEED RANGE—RPM	MOTOR CONSTANT OUTPUT SPEED RPM ±5%*
2 hp	300 to 3000	1200
3 hp	450 to 3000	1800
4 hp	600 to 2500	2400
6 hp	800 to 2400	3000
8 hp	850 to 2300	3300
9 hp	950 to 2200	3600

*Under normal rated load conditions, motor output speed can be held constant within ±5%.

Typical applications for Sundstrand hydrostatic transmissions include: Alternator drives on construction and fire-fighting equipment, refrigeration compressor drives, fan drives in air conditioned buses, and conveyor drives on agricultural, construction and mining equipment.

Sundstrand hydrostatic transmissions can be the answer to your power requirements. Get more facts by sending a brief outline of your needs to address below.

SUNDSTRAND

SUNDSTRAND HYDRAULICS

DIVISION OF SUNDSTRAND CORPORATION

2210 Harrison Ave., Rockford, Ill.—Eastern Sales Office: 80 Summit Ave., Summit, N. J.

AIRCRAFT AND INDUSTRIAL HYDRAULIC TRANSMISSIONS, PUMPS, MOTORS AND VALVES • OIL BURNER PUMPS • AIR SANDERS • LATHES, MILLING, BROACHING AND SPECIAL MACHINES • BROACHING TOOLS • MAGNETIC CHUCKS • PACKAGING MACHINERY

yours

when you specify Hanna cylinders and valves

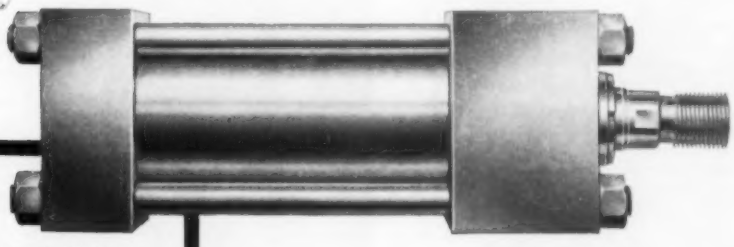
QUALITY • ECONOMY • SERVICE

Your specifications are a part of Hanna Cylinder and Valve design because you get the features you want plus quality, economy and service. In addition you have a complete selection of the most modern cylinders and valves available.

Hanna Cylinders and Valves furnish economical power for thousands of jobs. Not only are they economically priced, but the long life built into these products means that you will continue to operate at minimum cost.

The service offered by Hanna and its more than 60 sales representatives in the United States, Canada, and Foreign Countries can't be beat. Hanna Cylinders and Valves stocked at the Hanna factory and at many representatives' offices help solve your "needed now" problems. Because of efficient Hanna production, "built to order" cylinders take only a few days.

Be sure you specify *Hanna* for all your air and hydraulic Cylinders and Valves.



HANNA POWRDRAULIC HYDRAULIC CYLINDERS

2000 and 3000 psi non shock. 1½" through 8" bores.

FEATURING—Pressure Tightening Tube Seals • One Piece Steel Heads with Welded Mountings • Double Seal Piston Rings • Fast Change Cartridge Gland • Lubricated Bearing

Write for Catalog 900

HANNA T750 SERIES FLUID POWER CYLINDERS

Air to 250 psi, Hydraulic to 750 psi. 1½" through 4" bores. Ask for Catalog 750.

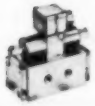
HANNA M AND MCC SERIES CYLINDERS

Air to 110 psi, Hydraulic to 150 psi. 5" through 14" bores. Ask for Catalog 236.

Opera- Unitite s. Cata- 254.

Flo-Set, Speed Control Valves. Bulletin 253.

Flo-Pilot, Pilot Valves. Catalog 262.



Flo-Line, Solenoid and Master Valves. Catalog 261.

Foot Operated Valves. Catalog 254.

Phone your nearest Hanna Representative listed in the yellow pages under "Cylinders".

YELLOW PAGES

anna Engineering Works

HYDRAULIC & PNEUMATIC EQUIPMENT • CYLINDERS • VALVES

1763 ELSTON AVENUE • CHICAGO, ILLINOIS

GAST ROTARY AIR MOTORS, COMPRESSORS, VACUUM PUMPS OFFER BIG ADVANTAGES AS ORIGINAL EQUIPMENT ON HUNDREDS OF PRODUCT APPLICATIONS . . .

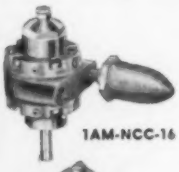
AIR MOTORS — 1/20 TO 7 H.P.

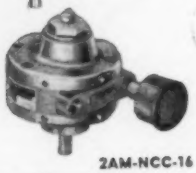
Explosion-proof Gast Air Motors give you amazing compactness and light weight for hp rating. You get the advantage of a wide range of variable speeds plus low speeds without stalling. They'll start in any position. They can't burn out from overloads. Rotor vanes take up their own wear. Simple, almost service free, Gast Rotary Air Motors "fill the bill" in many equipment applications with low first cost.

Specifications

Model No.	R.P.M.	HORSE POWER At 60 P.S.I.	HORSE POWER At 90 P.S.I.	Net Wt. Lbs.
1 AM	2,000 5,000	0.11 0.21	0.13 0.30	1½
2 AM	1,000 2,000	0.22 0.40	0.35 0.57	5½
4 AM	1,000 2,000	0.48 0.78	0.73 1.10	8
6 AM	1,000 2,000	0.80 1.30	1.30 2.00	17
8 AM	1,000 2,000	1.60 2.80	2.30 4.20	25
16 AM	1,000 2,000	2.70 4.20	4.20 7.00	65

4AM-FCC-1C


1AM-NCC-16


2AM-NCC-16

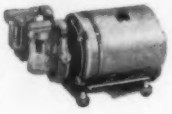
AIR COMPRESSORS — FROM .6 TO 45 C.F.M.

Integral (motor-pump) — Compact, light weight, efficient "package" units. Vanes take up their own wear. Compressor rotor mounted on motor shaft for quiet, pulseless air delivery.

Light-Duty — For intermittent service. Quick pick-up, positive displacement. Resemble heavy-duty models but without fans or deep cooling fins, not needed for brief operating periods. Simpler lubricator. (Not illustrated.)

Heavy-Duty — Fan-cooled — for long, continuous operation. Rotary design gives more air per lb., per hp. Automatic lubricator has self shut-off.

Model	Model No.	Cfm.	Rec. Max. Pressure Psi: Continuously	Rec. Max. Pressure Psi: 10 Min. On-Off	Hp.	Net Wt.* Lbs.
Integral (Motor Compressor)	0406	0.6	15	20	1/12	16
	0211	1.3	15	25	1/6	22
	0321	2.2	20	25	1/4	25
	0521	3.8	15	20	1/3	26
Light-Duty	0240	2.0	10	20	1/4	8
	0440	4.0	10	20	1/3	10
	0740	5.6	7	10	1/3	11
	1550	10.0	10	15	3/4	29
	3040	24.2	10	15	2	68
Heavy-Duty Fan-Cooled	0465	4.0	25	30	1/2	18
	0765	5.6	10	15	1/2	18
	1065	8.3	25	30	1	34
	2065	17.0	15	20	1½	54
	2565	21.0	15	20	2	54
	4565	43.0	15	20	5	92


0211-P3A-G10X

2065-P10-G42

*Weight without base or motor, except integral models.

VACUUM PUMPS — FROM .6 TO 45 C.F.M.

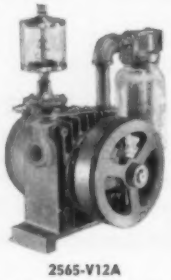
Integral (motor-pump) — Compact, light weight, "packaged" units. Save mounting cost and time. Especially suited for portable equipment. Rotor mounted on motor shaft. Rotary design gives quiet operation, pulseless vacuum. Vanes take up own wear.

Light-Duty — For intermittent service. Give quick pick-up, trouble-free performance. Resemble heavy-duty models but without external fans or deep cooling fins. Simpler lubricator.

Heavy-Duty — Fan-cooled — Built for continuous service, dependability, minimum maintenance. Forced air cooling, deep cooling fins. Automatic lubricator has self shut-off.

Model	Model No.	Cfm.	Rec. Max. Vacuum, in Hg.: Continuously	Rec. Max. Vacuum, in Hg.: 10 Min. On-Off	Hp.	Net Wt.* Lbs.
Integral (Motor Pump)	0406	0.6	15	25	1/12	16
	0211	1.3	15	27	1/6	22
	0321	2.2	28		1/4	27
	0521	3.8	28		1/3	28
Light-Duty	0240	2.0	15	26	1/4	9
	0440	4.0	15	26	1/4	11
	0740	5.6	10	26	1/3	12
	1550	10.5	15	25	1/2	29
	3040	24.0	15	26	1½	68
Heavy-Duty Fan-Cooled	0465	4.0	28		1/4	18
	0765	5.6	28		1/3	18
	1065	8.3	28		1/2	34
	2065	17.0	28		1	54
	2565	21.0	28		1½	54
	4565	48.0	20	28	3	92

0406-V2-154X


2565-V12A

1550-V2A

*Weight without base or motor, except integral models.

OIL-LESS AIR PUMPS

3040-V103

Available in 5 sizes, separate drive — 2 sizes, integral-motor.

Write for "Oil-less" Bulletin.

Gast offers you specialized experience in air motors, compressors and vacuum pumps for original equipment. Based on numerous types and sizes, over 200 different Gast models go into production each year. With the various accessories, these models have a tremendous number of applications.

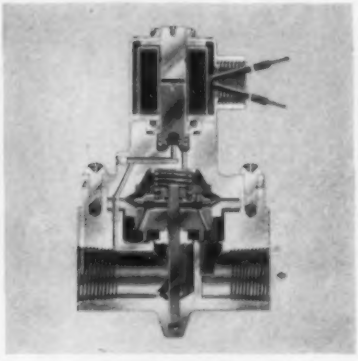
WRITE TODAY for "Application Ideas" Booklet and Catalog, or Data on any model.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY AIR MOTORS • COMPRESSORS • VACUUM PUMPS
(To 7 Hp.) (To 30 Lbs.) (To 28 Inches)
GAST MANUFACTURING CORP. P.O. Box 117 L Benton Harbor, Mich.

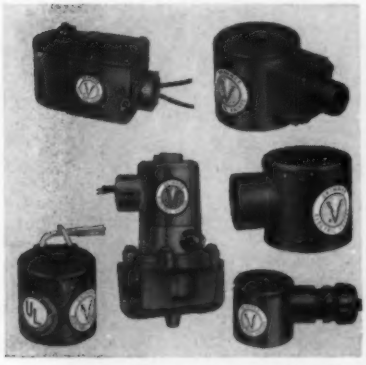
Skinner 2-way Solenoid Valves provide High Flow at Low Cost

Unusually low-cost model... the LC2 valve. A small, light, normally closed valve. Permits full flow through 1/2" orifice with 3/8" or 1/2" NPT ports. Will control all common media: air, oil, water, etc. Handles pressures from 5 psi to 150 psi, with temperature ranges from minus 40°F to plus 180°F, and will operate on all popular AC and DC voltages.



Features of L Series valves. Like all Skinner valves, these are built to UL standards. Their bodies are made of forged naval brass and their internal parts are stainless steel and brass. Soft, synthetic inserts and seals provide bubbletight operation. And a unique, Buna-N coated nylon diaphragm assembly assures long life. They mount in any position directly to the line. A variety of coils for common AC and DC voltages is available.

Full extent of line includes L2 models featuring 1/2" orifice with 3/8" or 1/2" NPT ports, 3/4" and 1" orifices with 3/4" and 1" NPT ports. At greatly reduced cost, these valves permit applications not possible before. They are available normally open or normally closed in standard or explosion-proof construction.



Custom installation can be had with these options. There is a large selection of electrical housings that can be rotated 360° for easy connecting. Also available for these L2 valves is manual override that permits opening or closing of the valve in the event of a current failure.

For quickest service, write for Skinner's Nationwide Stock List. It covers all of the valves universally stocked by Skinner distributors and includes a number of the L Series valves. From this list, your local Skinner distributor can quickly meet your requirements.

A complete line. There's a Skinner solenoid valve for almost any flow application with a wide variety of media: air, oil, water, inert gases, hydraulic fluids, kerosene and gasoline. Orifice sizes range from 3/64" to 1". Pressure ratings range from vacuum to 3000 psi. Explosion-proof models are UL approved for Class 1, Group D and Class 2, Groups F and G.

Skinner solenoid valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 459.

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SKINNER ELECTRIC VALVES

THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT

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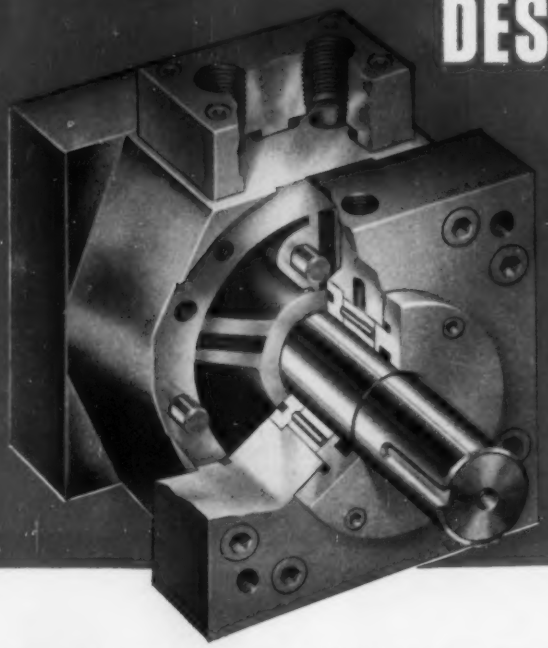

RŌTAC

Reciprocating Rotary Torque Actuators

Rōtac units illustrated are standard Model HN (at right), Model RN (top left); bottom, special Rōtac actuator delivers 1,400,000 in./lbs. torque at 1,000 psi.

Rōtac gives greater design flexibility wherever you need *movement, instant torque, and a compact power package!* From 26 catalogued models you can draw on 312 "standard modifications" —to meet your special needs in size, torque, load, travel, temperature or operating pressure. Engineering service is available for unusual applications.

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59-R-46

HOW CAN YOU USE RŌTAC?

Rōtac Actuators simplify design, production and maintenance in such industries as foundry and heavy machinery, precision machine tools, automated production equipment, marine, mobile and materials handling, paper, printing and plating. Here are some typical uses:

Continuous rotation • Lift—lower • Oscillate • Index—position • Screw clamp • Toggle—cam pushing • Load-unload • Transfer • Press • Intermittent feed • Turnover • Constant tension • Conveyor turn or stop

FREE DESIGN DATA BOOK—20 pages on how Rōtac works, torque ratings, control, dimensions, installation, typical applications and special uses. See your Rōtac Representative or write direct.

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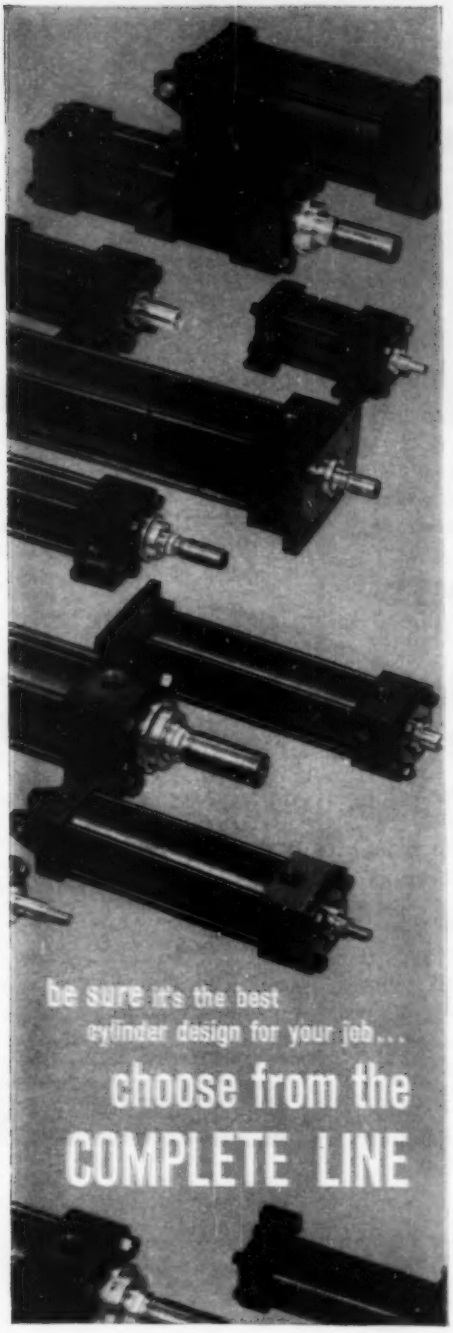
EX-CELL-O PRECISION PRODUCTS INCLUDE: MACHINE TOOLS • GRINDING AND BORING SPINDLES • CUTTING TOOLS • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • TORQUE ACTUATORS • THREAD AND GROOVE GAGES • GRANITE SURFACE PLATES • AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS • DAIRY EQUIPMENT



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Only Hydro-Line offers you the "Complete Line" of three series of industry standard, modern design cylinders enabling you to choose the type best suited to your job requirements. You needn't pay for "too much" cylinder for the job, nor do you have to "stretch" and risk tying up production by not buying "enough" cylinder.

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series N — 2000 psi and higher hydraulic service; 1½" to 12" bores; meet J I C standards.

series S2 — 200 psi air, 1000 psi hydraulic, ½" to 8" bores; meet J I C and automotive industry automation standards.

For more complete data on sizes carried in factory stocks — covering 90% of applications and including thousands of bore, stroke and cushion combinations, contact your nearby Hydro-Line representative or fill in coupon below and send direct to factory:

act now!

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( ) Series S2 (automotive industry automation standards)

Name and Title_____
Company_____
City_____ State_____

HYDRO-LINE MANUFACTURING COMPANY
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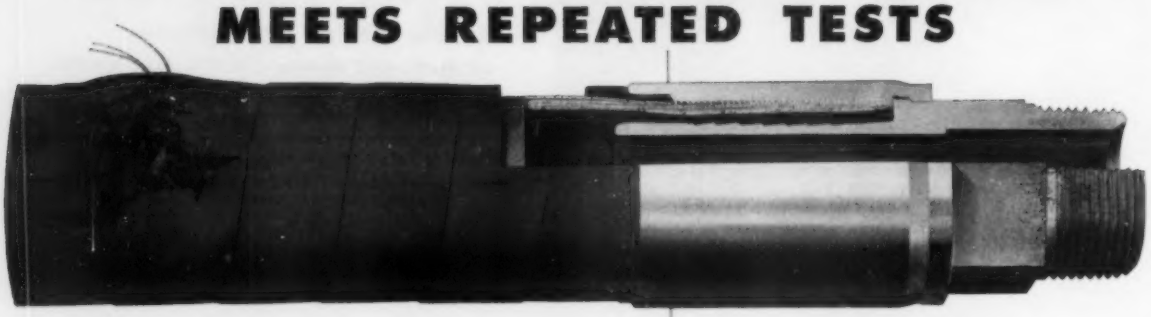
manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

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Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.

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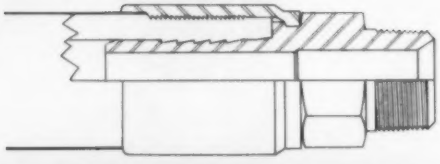
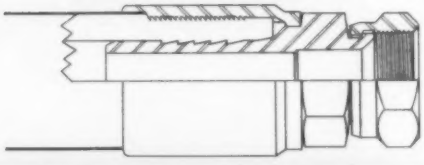
MALE NPTF



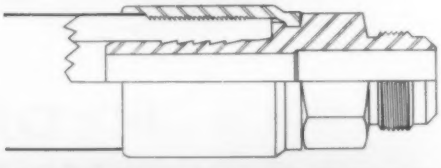
Catalog No.	Hose I.D. (inches)	Hose O.D. (inches)	Coupling I.D. (inches)	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
8412-12M	¾	1 7/16	19/32	20,000	5,000
8416-16M	1	1 ¾	25/32	16,000	4,000
8420-20M	1 ¼	2	1 3/64	12,000	3,000
8424-24M	1 ½	2 ¼	1 31/64	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D. (inches)	Hose O.D. (inches)	Coupling I.D. (inches)	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
8412-12FH	¾	1 7/16	19/32	20,000	5,000
8416-16FH	1	1 ¾	25/32	16,000	4,000
8420-20FH	1 ¼	2	1 3/64	12,000	3,000
8424-24FH	1 ½	2 ¼	1 31/64	10,000	2,500

MALE JIC-37°



Catalog No.	Hose I.D. (inches)	Hose O.D. (inches)	Coupling I.D. (inches)	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
8412-12MH	¾	1 7/16	19/32	20,000	5,000
8416-16MH	1	1 ¾	25/32	16,000	4,000
8420-20MH	1 ¼	2	1 3/64	12,000	3,000
8424-24MH	1 ½	2 ¼	1 31/64	10,000	2,500

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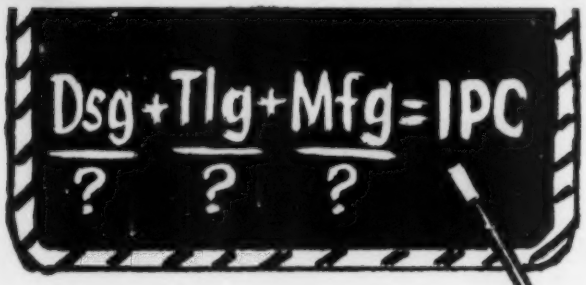

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9. Bonded Case Seal Straight Lip With Garter Spring
11. Bonded Case Seal Straight Lip Thin Rind Type
13. Rubber Covered Bonded Case Seal Straight Lip
15. Rubber Covered Bonded Case Seal Straight Lip With Garter Spring
2. Bonded Case Seal Double Lip Wiper
4. Bonded Washer Seal Limited Contact Lip
6. Bonded Washer Seal Limited Contact Lip With Garter Spring
8. Bonded Case Seal Limited Contact Lip
10. Bonded Case Seal Limited Contact Lip With Garter Spring
12. Bonded Case Seal Limited Contact Lip Thin Rind Type
14. Rubber Covered Bonded Case Seal Limited Contact Lip
16. Rubber Covered Bonded Case Seal Limited Contact Lip With Garter Spring

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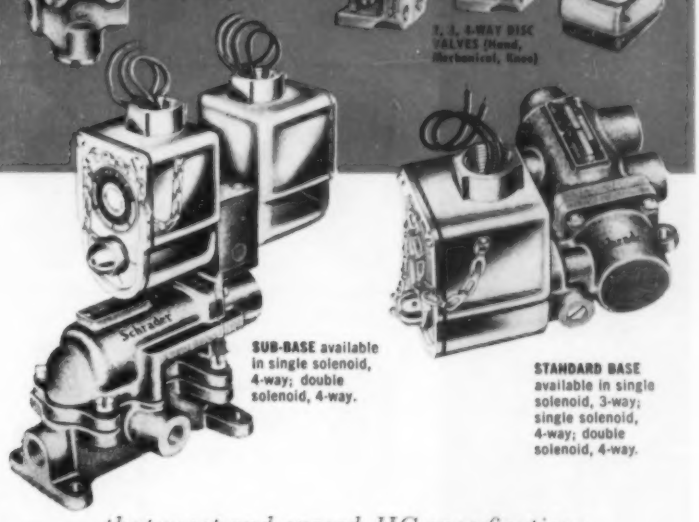
AND NOW...

NEW JIC SOLENOID AIR VALVES

..... that meet and exceed JIC specifications



SUB-BASE available in single solenoid, 4-way; double solenoid, 4-way.

STANDARD BASE available in single solenoid, 3-way; single solenoid, 4-way; double solenoid, 4-way.

New JIC Solenoid Valves are compact, rugged, fast-and-easy to install. Roomy junction boxes fit space requirements with 90° rotation. Can be operated in case of current failure, by hand. Safe, recessed override button prevents accidental operation. Electrical system completely sealed against dust, oil.

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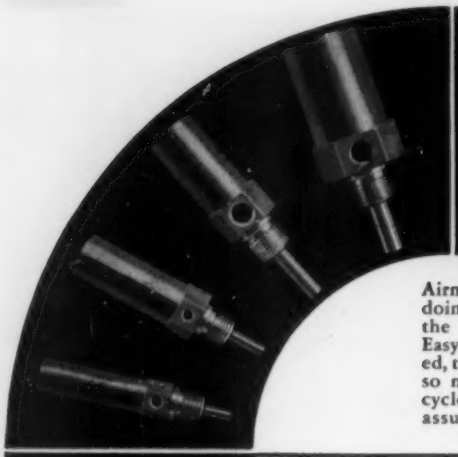

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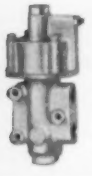
2-Way Cam Controlled ¼" - 2"

3-Way Pilot Operated ⅛" - 1"

3-Way Cam Controlled ⅛" - 1"

3-Way Direct Solenoid ⅛" - 1"



3-Way Sequence Time-Delay ¼" - ¾"

3-Way Solenoid Pilot ¼" - 1"

Pressure Regulator

Pipeline Strainer

4-WAY MASTER VALVES

PILOT

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SOLENOID

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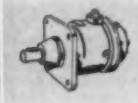
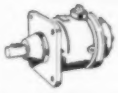
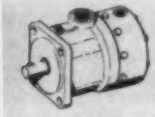
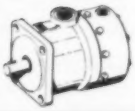
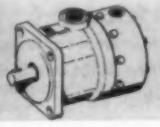
	4000 psi	PF 4004 (2.1 gpm @ 1200 rpm)	VR 3108 VR 9103	VD 4103 (0-3 gpm) VM 3506 (0-6 gpm) VM 6506 (0-10 gpm) VM 6106 (0-8 gpm)
15 hp range	3000 psi	PF 3008 (5.7 gpm)	VR 3108	VM 3506 (0-6 gpm) VM 6506 (0-10 gpm) VM 6106 (0-8 gpm)
	6000 psi	PF 6006 (4.2 gpm)	VR 6108	VM 6506 (0-10 gpm) VM 6106 (0-8 gpm)
30 hp range	3000 psi	 PF 3016 (10.9 gpm)	VR 3120	VM 6512 (0-16 gpm) VM 6520 (0-30 gpm)
	6000 psi	 PF 6011 (7.9 gpm)	VR 6120	VM 6506 (0-10 gpm) VM 6512 (0-16 gpm) VM 6520 (0-30 gpm)
45 hp range	3000 psi	 PF 3021 (14.7 gpm)	VR 3120	VM 6512 (0-16 gpm) VM 6520 (0-30 gpm)
	6000 psi	 PF 6015 (10.5 gpm)	VR 6120	VM 6512 (0-16 gpm) VM 6520 (0-30 gpm)
90 hp range	6000 psi	 PF 6028 (21.5 gpm)	VR 6120	VM 6520 (0-30 gpm)

Complete line of single and double acting cylinders for every application

All pumps have split flow feature to provide two or more separate circuits. Write for engineering data sheets on the above circuits and components.

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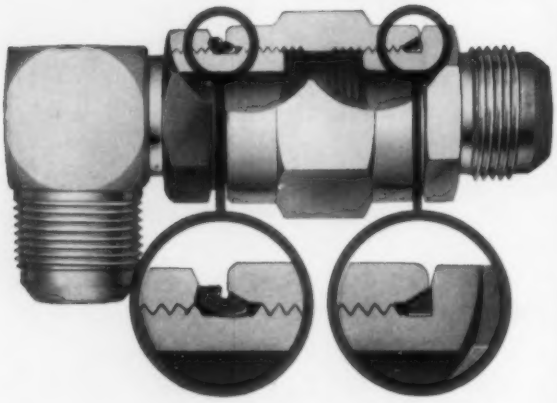

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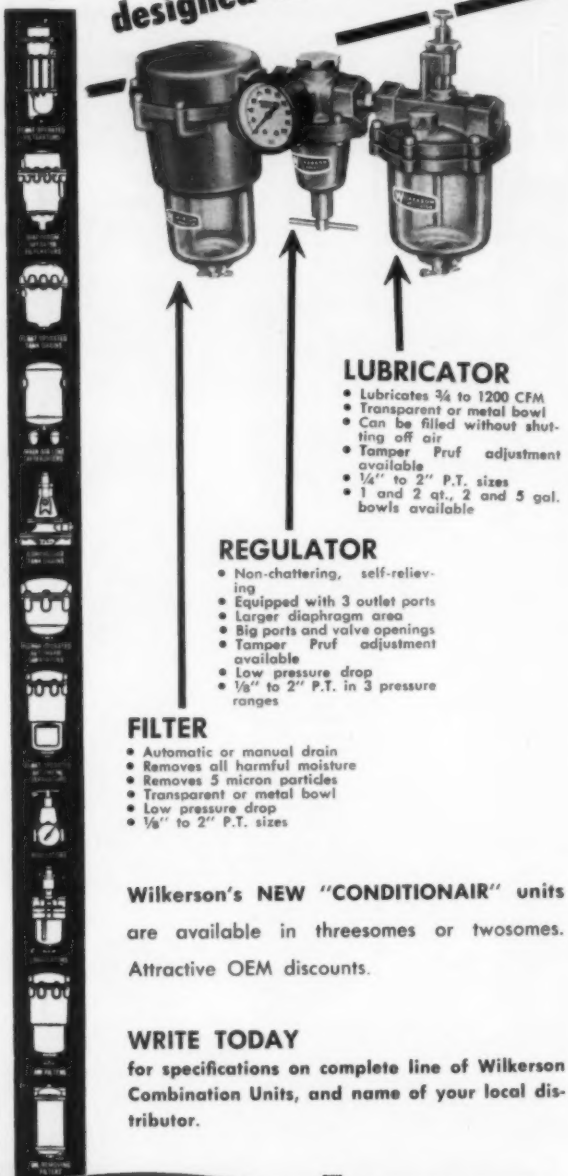

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- Low pressure drop
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catalogs and bulletins.....continued

(J-61) High Production Chucking Equipment—Catalog, 33 pp. Engineering and ordering information on power chucks, rotating air and hydraulic cylinders, valves and accessories. The S-P Mfg Corp, 30201 Aurora Rd, Solon, Ohio.

(J-62) Airmotor—Bulletin, 8 pp. Explains operation of cylinder and electric control valve air power package. Includes specifications, dimensions, mounting styles and product features. Hannifin Co, Div of Parker-Hannifin Corp, 525-D South Wolf Rd, Des Plaines, Ill.

(J-63) Nonrotating Fluid Cylinders—Catalog, 10 pp. Shows dimensional data on models, mountings, bores, piston rods and rod ends, pressure and volume applications. The S-P Mfg Corp, 30301 Aurora Rd, Solon, Ohio.

(J-64) High-pressure Hydraulic Cylinders—Catalog, 8 pp. Dimensional data on models, mountings, bores, piston rods and rod ends. Engineering data on this cylinder and hydraulic pressure and flow data. The S-P Mfg Corp, 30201 Aurora Rd, Solon, Ohio.

(J-65) Hydraulic Components—Catalog, 25 pp. Hydraulic pumps, motors, valves and cylinders. Wisconsin Hydraulics, Inc, 3165 N 30th St, Milwaukee, Wis.

(J-66) High and Low Pressure Cylinders—Catalog, 8 pp. Shows illustrations and specifications of cylinders and their applications. Walter Kidde & Co, Inc, 669 Main St, Belleville 9, NJ.

(J-67) Ball Valves—Catalog, 30 pp. Describes ¼ in. to 8 in. double seal ball valves and actuating devices giving materials, specifications and advantages. Jamesbury Corp, 45 New St, Worcester, Mass.

(J-68) Flexible Connector Assemblies—Catalog, 60 pp. Describes construction, properties, uses, specifications, materials, installation and ordering. The American Brass Co, American Metal Hose Div, 698 South Main St, Waterbury 20, Conn.

(J-69) Flexible Teflon Connector Assemblies—Bulletin, 16 pp. Describes construction, properties, uses, specifications, ordering instructions. The American Brass Co, American Metal Hose Div, 698 S Main St, Waterbury 20, Conn.

(J-70) Pumps—Bulletin, 16 pp. Contains parts list, performance curves, dimension drawings and installation information. The Duriron Co, Inc, 450 N Findlay St, Dayton, Ohio.

(J-71) Industrial Couplings—Brochure, 4 pp. Describes the operation and applications as well as engineering data, dimensions and test results. Illustrated with drawings, graphs and photographs. Airaterra, 620 Paula Ave, Glendale, Calif.

(J-72) Rubber Hose and Fittings—Bulletin, 12 pp. Detachable, reusable hose fittings and flexible hose assemblies for all types of industrial applications. Stratoflex, Inc, 220 Roberts Cut-off, Ft Worth, Tex.

(J-73) Hydraulic Cylinders—Catalog, 60 pp. Photos, drawings and tables of dimensions and specifications of complete line of double and single acting, telescopic, and special hydraulic cylinders for pressures to 1500 psi. Data on mountings and fittings. Commercial Shearing & Stamping Co, Youngstown 1, Ohio.

(J-74) Hydraulic Pumps and Motors—Catalog, 64 pp. Performance data, mountings, dimensions, construction details and features of complete line of single fluid power pumps, fluid power motors, and tandem pumps for pressures to 1500 psi. Commercial Shearing & Stamping Co, Youngstown, 1, Ohio.

(J-75) Hydraulic Control Valves—Catalog, 9 pp. Includes pressure drop curves and other performance data, dimensions, features, circuitry of complete line of fluid power control valves, unit and multiple, pressures to 2000 psi. Commercial Shearing & Stamping Co, Youngstown 1, Ohio.

(J-76) Quick-connect Couplings—Catalog, 50 pp. Describes construction and lists complete line of couplings and compression type reusable hose clamps. The Hansen Mfg Co, 4031 W 150th St, Cleveland 35, Ohio.

(J-77) Fluid Power Equipment—Catalog, 4 pp. Information on equipment such as cylinders, valves, air control device and packaged units. Modernair Corp, 400 Preda St, San Leandro, Calif.

(J-78) Air-cooled Condensers—Bulletin, 4 pp. Gives dimensional details and selection information for refrigeration and air conditioning applications up to 15 tons. Bohn Aluminum & Brass Corp, Betz Div, 1625 E Voorhees St, Danville, Ill.

(J-79) Sealless Pumps—Catalog, 4 pp. Describes construction and recommended uses of small canned rotor pumps that eliminate shaft seals and lubrication problems. Fostoria Pressed Steel Corp, N Main St, Fostoria, Ohio.

(J-80) Cylinders—Catalog, 64 pp. Standard and valve-in-head cylinders with sizes, price lists and engineering data. Allenair Corp, 255 E 2nd St, Mineola, NY.

(J-81) High-vacuum Equipment—Catalog, 8 pp. Describes entire line of helium leak detectors, vacuum evaporators and pumping stations, valves, gages, pumps and accessories. Veeco Vacuum Corp, 86 Denton Ave, New Hyde Park, NY.

(J-82) Hydraulic Servovalves—Catalog, 6 pp. Written and graphic description of operational procedure and characteristics with schematic drawings and terminology explanation on pressure control hydraulic servovalves. Moog Valve Co, Inc, Proner Airport, East Aurora, NY.

(J-83) Bronze and Iron Body Valves—Catalog, 136 pp. Illustrates and describes with basic specifications complete line of bronze and iron body valves. The Fairbanks Co, 393 Lafayette St, New York 3, NY.

catalogs and bulletins.....continued

(J-84) Oil Bath Air Filters—Catalog, 8 pp. Designed for air intake of engines, compressors and pressure blowers. Air-Maze Corp, 25000 Miles Rd, Cleveland 28, Ohio.

(J-85) Liquid Filters—Catalog, 16 pp. Intended for full flow filtration of lubrication, hydraulic and fuel oils. Air-Maze Corp, 25000 Miles Rd, Cleveland 28, Ohio.

(J-86) Cylinders—Catalog, 8 pp. Gives installation dimensions, specifications, cross-sections and application guidance, as well as engineering information. The Airoyal Mfg Co, 1990 Springfield Ave, Maplewood, NJ.

(J-87) Accumulators—Bulletin, 2 pp. Shows exterior and interior design, describes performance and gives capacities, dimensions and pressures. Special Products Co, 15000 W 44th Ave, Denver, Colo.

(J-88) Valves and Accessories—Catalog, 244 pp. Gives specifications, dimensions and other engineering information on valves, fire hydrants and accessories. Darling Valve & Mfg Co, Campbell St, Williamsport, Pa.

(J-89) Directional Air-control Valves—Bulletin, 12 pp. Discussion of air valves and their selection together with condensed listing of all company valves. Outline covering valve types, means of actuation and operating principles. Hannifin Co, Division of Parker-Hannifin Corp, 525-D S Wolf Rd, Des Plaines, Ill.

(J-90) Fluid Controls—Catalog, 47 pp. Information on line of steam traps; including inverted bucket, thermostatic, float, pumping and venting traps. Data file gives information for properly selecting and sizing traps for all applications. Information also included on pressure regulators and reducing valves. The Clark Mfg Co, 1830 E 38th St, Cleveland 14, Ohio.

(J-91) Solenoid Valves—Catalog, 31 pp. Description of solenoid valves for use in any media, either liquid or gas at pressures from zero to 10,000 psi. Atkomatic Valve Co, Inc, 545 W Abbott St, Indianapolis, Ind.

(J-92) Valves and Fittings—Catalog, 58 pp. Engineering information and specifications on a general line of valves and fittings for fluid control. Controls Co of America, 2450 N 32nd St, Milwaukee, Wis.

(J-93) Liquid Filters—Bulletin, 4 pp. Includes specifications, maintenance, installation, testing and application parts on all models of liquid filters. Filtros, Inc, 601 Commercial St, East Rochester, NY.

(J-94) Plastic Gate Valve—Catalog, 4 pp. Characteristics, applications, sizes and features of flow control device. Illustrated with drawings and graphs. Vanton Pump and Equipment Corp, Div of Cooper Alloy Corp, 201 Sweetland Ave, Hillside, NJ.

(J-95) Hydraulic Components—Bulletin, 4 pp. Summary of products and literature available. The Kraissl Co, Inc, 299 Williams Ave, Hackensack, NJ.

(J-96) Circulating Pump—Brochure, 4 pp. Design specifications, performance charts and outline drawing, Taco Heaters, Inc, 1160 Cranston St, Cranston 9, RI.

(J-97) Cylinders and Valves—Bulletin, 36 pp. Describes construction and gives engineering information on 1000 and 2000 psi hydraulic cylinders and directional control valves. Includes charts and photographs of models. Pathon Mfg Co, 3823 Pacific Ave, Cincinnati 12, Ohio.

(J-98) Hydraulic Power Units—Catalog, 20 pp. Describes and illustrates line of hydraulic power units for feeding and rotating cutting tools. Gives specifications, engineering information, shows applications. Ex-Cell-O Corp, 1200 Oakman Blvd, Detroit 32, Mich.

(J-99) Hydraulic Pumps and Controls—Catalog, 56 pp. Gives performance and operating characteristics of industrial line: pumps, pressure and volume controls, transmissions and accessories. Vickers Inc, A&E Center, Detroit 32, Mich.

(J-100) Air and Low-pressure Hydraulic Cylinders—Bulletin, 35 pp. Describes construction and gives engineering information, installation and operating suggestions, and hydraulic applications. Pathon Mfg Co, 3823 Pacific Ave, Cincinnati 12, Ohio.

(J-101) Plastic Pumps—Catalog, 8 pp. Sealless pump for corrosive chemicals, foodstuffs, gases and others. Describes features, construction materials, typical uses and gives performance data. Vanton Pump & Equipment Corp, Div of Cooper Alloy Corp, 201 Sweetland Ave, Hillside, NJ.

(J-102) High-temperature Pumps and Motors—Brochure, 4 pp. Describes specifications, applications and performance curves on models with speeds to 24,000 rpm and temperature ranges from −65 F to +550 F. Pesco Products Div, Borg-Warner Corp, 24700 North Miles Rd, Bedford, Ohio.

(J-103) Air Cylinders—Bulletin, 8 pp. Describes line of 1½ in. to 14 in. bore air cylinders. Gives specifications, styles, component parts and mounting data. Mo-Bar Hydraulic Sales Co, Box 375, Crystal Lake, Ill.

(J-104) Dehydration Equipment—Brochure, 8 pp. Description and specifications of standard, high pressure, and heaterless compressed gas dryers and special purpose equipment. Kahn and Co, Inc, PO Box 516, Hartford 1, Conn.

(J-105) Air Motor—Brochure, 14 pp. Provides information on system of pneumatic control, bore sizes and developed thrust, material specifications and applications. The Bellows Co, 222 W Market St, Akron, Ohio.

(J-106) Hydraulic Controls—Brochure, 4 pp. Describes facilities and engineering service available for production and design of valves, cylinders, pumps and others. Hydraulic Unit Specialties Co, PO Box 257, Waukesha, Wisc.

(J-107) Feeders and Pump Controls—Bulletin, 8 pp. Describes and provides ordering information for feeder and cut-off combinations, pump controllers, pressure and temperature relief valves, and float operated switches. McDonnell & Miller, Inc, 3500 N Spaulding, Chicago 18, Ill.

(J-108) Valve Operator—Bulletin, 4 pp. Describes construction, application and operation for remote, automatic or push-button control of flow valves. Pelton Division, B-L-H Corp, 2929 19th St, San Francisco 10, Calif.

(J-109) Hydraulic Cylinders—Catalog, 7 pp. Describes hydraulic cylinders for operating pressures up to 3000 psi. Available in both tie rod and welded designs. Dukes Co, Inc, 3999 North 25th Ave. Schiller Park, Ill.

(J-110) Tube Fittings—Catalog, 28 pp. Provides engineering, performance and application data on flareless tube fitting that creates a butt joint. Furnished in steel, stainless steel, brass and other metals. The Imperial Brass Mfg Co, 6300 W Howard St, Chicago, Ill.

(J-111) Air and Hydraulic Valves—Bulletin, 16 pp. Describes control assemblies and body types with manual, electric, direct or remote actuation. Valvair Corp, Div of IBEC, 454 Morgan Ave, Akron, Ohio.

(J-112) Valve Actuators—Bulletin, 4 pp. Describes types, mountings and torque capacities. Designed for pressures up to 200 psi. Ledeen Mfg Co, 3350 N Gilman Rd, El Monte, Calif.

(J-113) Condensing Units—Catalog, 4 pp. Gives specification and capacity data for air and water cooled, high and low temperature models. Describes component parts, assembly and operation. Bendix-Westinghouse Automotive Air Brake Co, 950 E Virginia St, Evansville, Ind.

(J-114) Fluid Power Equipment—Bulletin, 8 pp. Describes various types of fluid pumps, oil motors and control valves. Includes ratings, capacities and selection data. Hydreco Div, The New York Air Brake Company, 9000 E Michigan Ave, Kalamazoo, Michigan.

(J-115) Magnetic Shaft Seals—Brochure, 4 pp. Describes component parts and operation. Photos, tables, and cut-away drawings give dimensions and construction information. Magnetic Seal Corp, Oak Grove Ave & Sowams Rd, Barrington, RI.

(J-116) Valves—Bulletin, 12 pp. Describes construction features, dimensions and operations. Diagrams, photographs and charts are provided. Hunt Valve Co, Salem, Ohio.

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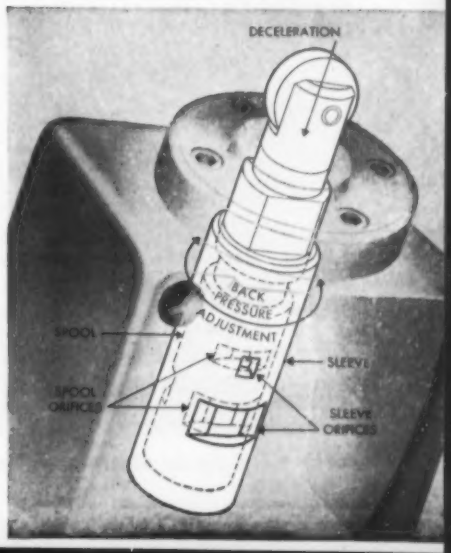

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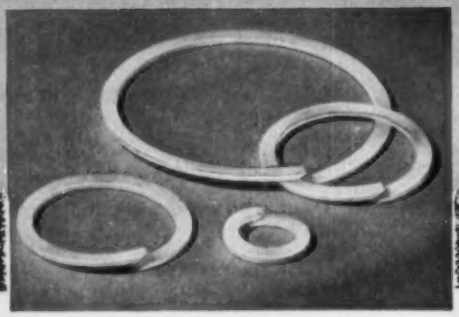

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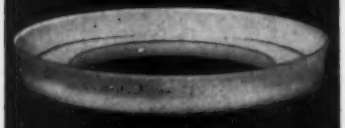

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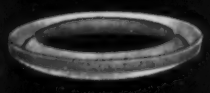

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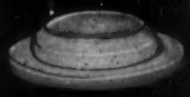

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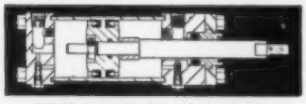

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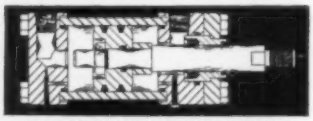

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catalogs and bulletins.....continued

(J-117) Control Valves—Catalog, 16 pp. Describes valve types, operation, standard specifications and sizes. In addition, methods of controlling valve operation are covered. Ross Operating Valve Co, 114 E Golden Gate Ave, Detroit 3, Mich.

(J-118) Hydraulic Tube Fittings—Catalog, 27 pp. Provides selection, assembly and operational information for line of fittings. Includes specifications, drawings and clearance charts. Flodar Corp, 16911 St Clair Ave, Cleveland, Ohio.

(J-119) Displacement Pumps—Catalog, 12 pp. Information on sliding vane, internal and external gear pumps, and pump-motor combinations, including selection guide. Tuthill Pump Co, 939 E 95th St, Chicago 19, Ill.

(J-120) Air and Hydraulic Cylinders—Bulletin, 11 pp. Lists construction features, maximum operating pressures, selection formula, mounting recommendations, maintenance data and information on forces required for acceleration and deceleration. Bores 1½ in. to 14 in., 500-2500 psi hydraulic, 200 psi air. Hydro-Line Mfg Co, Rockford, Ill.

(J-121) Screw Pumps—Catalog, 4 pp. Contains information on typical diameters, construction, testing, applications and ordering. Uses charts, diagrams and photographs to illustrate features and operation. Sier-Bath Gear & Pump Co, 9252 Hudson Blvd, North Bergen, NJ.

(J-122) Air and Hydraulic Cylinders—Bulletin, 13 pp. Gives construction features, maximum operating pressures, force factor chart, selection and mounting data. Hydro-Line Mfg Co, 5600 Pike Rd, Rockford, Ill.

(J-123) Servovalves—Bulletin, 4 pp. Describes construction, gives specifications, flow curve, frequency response information and operational drawings. Pegasus Laboratories, Inc, 3690 W Eleven Mile Rd, Berkley, Mich.

(J-124) Seals—Catalog, 24 pp. Contains data on dimensions, rubber compounds, military specifications, installation and selection. Illustrated with photographs, charts and drawings. Minnesota Rubber Co, 3630 Wooddale Ave, Minneapolis, Minn.

(J-125) Stainless Steel Valves—Brochure, 14 pp. Describes production process for valves, fittings and custom castings: design, pattern making, molding, finishing and other operations. Also, plastic products. Cooper Alloy Corp, Vanton Pump and Equipment Corp, Hillside, NJ.

(J-126) Thermocouple Assemblies—Catalog, 36 pp. Contains prices, assembly instructions, construction features, range of operation and ordering information. Also includes temperature curves, graphs and outline drawings. Pressure sealing devices are also covered. Conax Corp, 2300 Walden Ave, Buffalo 25, NY.

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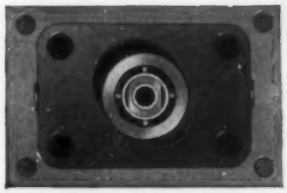

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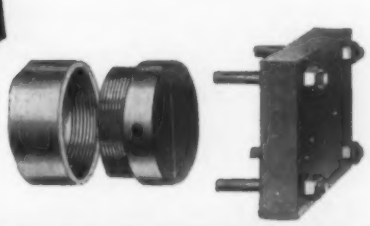
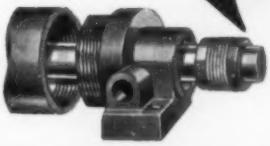


For the Maintenance Man



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FLUID OPERATED AND CONTROL EQUIPMENT

catalogs and bulletins.....continued

(J-127) **Hydraulic Equipment**—Brochure, 7 pp. Describes application of hydraulic structures to production machinery consisting of: self-contained power and control units, including feed and traverse pumps, directional control valves and hydraulic actuators. John S Barnes Corp, 301 S Water St, Rockford, Ill.

(J-128) **Air and Vacuum Pumps**—Catalog, 16 pp. Contains information on rotary positive air and vacuum pumps, air motors and gas boosters: performance curves, physical dimensions, applications and accessories. Leiman Bros, Inc, PO Box 1339, 146-181 Christie St, Newark 1, NJ.

(J-129) **Air Cylinders**—Bulletin, 6 pp. Description of line of interchangeable cylinders, mounting styles and bores from 1½ in. to 8 in. in diameter. Tomkins-Johnson Co, 2425 W Michigan, Jackson, Mich.

(J-130) **Hydraulic Directional Control Valves**—Catalog, 12 pp. Describes spool actions and styles of models for operating pressures up to 3000 psi. Notes on operation, mounting and assembly. Dukes Co, Inc, 3999 N 25th Ave, Schiller Park, Ill.

(J-131) **Hydraulic, Pneumatic and Propulsion Valves**—Brochure, 8 pp. Presents general engineering data with illustrations on missile and aircraft valves used for airborne and ground support applications. Units shown are also suitable for specialized industrial service. Penu-Hydro Valve Corp, 52 Horse Hill Rd, Cedar Knolls, NJ.

(J-132) **Fluid Control Valves**—Bulletin, 2 pp. Describes various types of valves for pressures up to 5000 psi. Includes specifications, dimensions and operational drawings. Mo-Bar Hydraulic Sales Co, Box 375, Crystal Lake, Ill.

(J-133) **Pneumatic Systems and Components**—Bulletin, 4 pp. Design and application information on basic aircraft systems and controls: air conditioning, fuel proportioners, ASW equipment, and others. Stratos, A Div of Fairchild Engine and Airplane Corp, Orinoco Drive, Bay Shore, NY.

(J-134) **Valves**—Bulletin, 12 pp. Gives engineering information and model numbers of 3- and 4-way valves of ⅛ in. and ¼ in. npt, with pressures to 125 psig. Includes information on palm, lever, ball actuated, pilot and solenoid valves. Hunt Valve Co, 1900 E Pershing St, Salem, Ohio.

(J-135) **Solenoid Valves**—Catalog, 47 pp. Describes operation, installation and maintenance of bronze and stainless steel models; pressures to 1200 psi, sizes ⅛ in. to 4 in. J D Gould Co, 4707 Massachusetts Ave, Indianapolis 18, Ind.

(J-136) **Air Motors**—Bulletin, 4 pp. Gives dimensions, specifications and performance curves for various models together with operational information and features. Joy Mfg Co, Oliver Bldg, Pittsburgh, Pa.

(J-137) **Relief Valves**—Catalog, 12 pp. Shows standard valves, brass and steel parts, dimensions, maintenance and installation information. The Fulflo Specialties Co, Inc, 410 Fancy, Blanchester, Ohio.

(J-138) **Air and Hydraulic Cylinders**—Brochure, 15 pp. Lists features, dimensions, selection and ordering information in addition to drawings, photographs and applications. Hydraulic panels for control valves are also covered. Petch Mfg Co, 463 York St, Detroit, Mich.

(J-139) **Liquid Processing Equipment**—Catalog, 39 pp. Includes filters mixers, pumps, and tanks; shows installations, various applications and cutaway views. Alsop Engineering Corp, Milldale, Conn.

(J-140) **Tube Fittings**—Catalog, 40 pp. Presents specifications, applications, assembly instructions and installation tools for tube fittings in machineable metal or plastic in sizes from ⅛ in. through 1 in. od. Crawford Fitting Co, 884 East 140th Street, Cleveland, Ohio.

(J-141) **Air Compressors**—Bulletin, 8 pp. Field pictures and limited specifications of stationary and portable models, and pneumatic tools used in construction, mining, petroleum and manufacturing markets. Le Roi Div, Westinghouse Air Brake Co, Milwaukee, Wisc.

(J-142) **Valves**—Bulletin, 4 pp. Describes construction, lists part numbers, and shows application of remote control valves which can be programed on a control panel. Ladish Co, Tri-Clover Div, 2809-60th St, Kenosha, Wisc.

(J-143) **Ram Actuators**—Bulletin, 4 pp. Contains information on materials, features, specifications, sizes and applications. Pegasus Laboratories, Inc, 3690 W Eleven Mile Rd, Berkley, Mich.

(J-144) **Pneumatic Equipment**—Brochure, 80 pp. Describes engineering program and facilities available for production of combustion equipment, pneumatic controls, couplings, and others. Janitrol Aircraft Div of Surface Combustion Corp, Columbus 16, Ohio.

(J-145) **Hydraulic and Pneumatic Units**—Catalog, 22 pp. Covers design and manufacture of landing gears, valves, cylinders and actuators. Also includes specifications, pressures and other technical data. Electrol Inc, 85 Grand St, Kingston, NY.

(J-146) **Pipe, Fittings and Valves**—Catalog, 12 pp. Describes PVC plastic piping components, properties and applications. Also provides information on installation and special features. Alpha Plastics, Inc, 78 Okner Parkway, Livingston, NJ.

(J-147) **Industrial Air Control Valves**—Catalog, 108 pp. Contains specifications, dimensional drawings, construction and application details on solenoid, pilot, cam, and manually operated heavy duty air control valves. Numatics, Inc, Highland, Mich.

(J-148) **Hose Couplings, Clamps and Nipples**—Catalog, 8 pp. Contains recommended uses, dimensions, construction materials and photographs of various couplings, clamps, nipples, valves and manifolds. Hose Accessories Co, Lehigh Ave & 17th St, Philadelphia 32, Pa.

(J-149) **Hydraulic Plugs**—Brochure, 8 pp. Explains operation of pin plugs together with specification charts, data on oversize holes, capabilities and charts. The Lee Co, Wesley Ave, PO Box 418, Westbrook, Conn.

(J-150) **Fluid Flow Probes**—Catalog, 20 pp. Applications and sizes of typical probes for measuring flow velocity, temperature and direction. Includes thermodynamic equations of flow. United Sensor & Control Corp, 122 Naubuc, Glastonbury, Conn.

(J-151) **Hydraulic Cranking Systems**—Catalog, 13 pp. Describes operation and applications for various types and sizes of gasoline and diesel engines. Includes basic systems, components, specifications and system diagrams. American Bosch Div of American Bosch Arma Corp, 3664 Main St, Springfield, 7, Mass.

(J-152) **Air Tanks**—Bulletin, 2 pp. Specifications, applications and dimensions of horizontal and vertical air receivers. Also contains construction and ordering information. Pressed Steel Tank Co, 1445 S 66th St, Milwaukee, Wisc.

(J-153) **Fluid Power Equipment**—Bulletin, 12 pp. Includes specifications, illustrations and descriptive matter on line of standard pumps, motors, cylinders, servo components, valves and accessories. The Oilgear Co, 1560 W Pierce St, Milwaukee 4, Wisc.

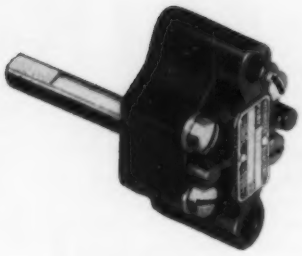
(J-154) **Oil Seals**—Catalog, 99 pp. Specification data and recommended sizes for design of various oil seal models of leather, felt or synthetic rubber. Albert Trostel Packings, Ltd, Lake Geneva, Wisc.

(J-155) **Pressure-vacuum Controls**—Catalog, 6 pp. Gives engineering information on complete line with charts showing specifications for the various model numbers. Also explains theory, operation and electrical features. United Electric Controls Co, 85 School St, Watertown, Mass.

(J-156) **Fluid Pumps**—Brochure, 8 pp. Describes various types, sizes, construction, capacities and applications. Sigmamotor, Inc, 3 N Main, Middleport, NY.

(J-157) **Air Compressors**—Bulletin, 4 pp. Portable high pressure air compressors suitable for breathing apparatus. Cornelius Co, Aero Div, 550—39th Ave NE, Minneapolis, Minn.

(J-158) **Safety and Relief Valves**—Catalog, 48 pp. Gives description of valves with specifications, applications, operational data. Also, construction and ordering information. Kunkle Valve Co, 121 South Clinton St, Fort Wayne 2, Ind.



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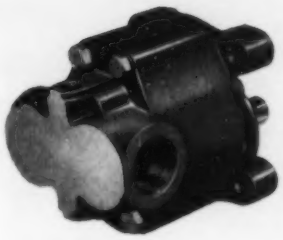

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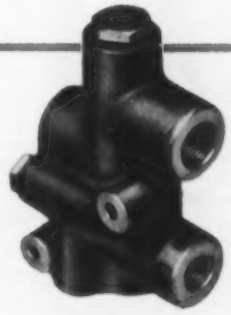

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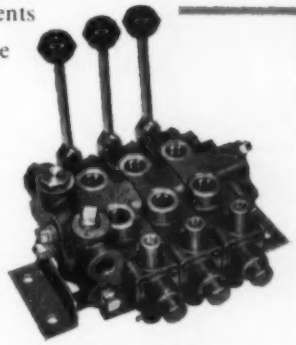

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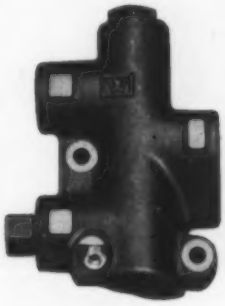

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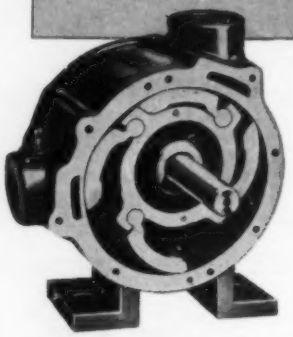

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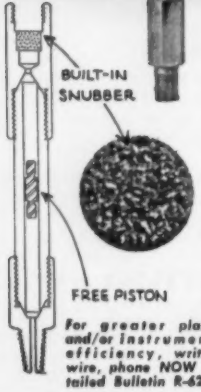

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(J-160) Pneumatic Controls—Bulletin, 26 pp. Consists of data sheets giving description, specifications, performance and engineering data of pneumatic controls for aircraft and missiles. Janitrol Aircraft Div, Surface Combustion Corp, 4200 Surface Rd, Columbus 4, Ohio.

(J-161) Lubricating Devices and Shaft Seals—Catalog, 118 pp. Contains dimensions, prices, outline drawings and applications for oilers, gages, lubricators, shaft seals, and others. Gits Bros Mfg Co, 1846-86 S Kilbourn Ave, Chicago 23, Ill.

(J-162) Pressure Regulators—Bulletin, 4 pp. Gives ranges, pipe sizes, pressure ratios and other data for different models. Includes graphs, charts and photographs. Stratos, Div of Fairchild Engine and Airplane Corp, Orinoco Drive, Bay Shore, NY.

(J-163) Hydraulic Rotary Actuator—Brochure, 17 pp. Describes data requirements for preparing design proposals and includes drawings of representative units for aircraft and missile application. Houdaille Industries, Inc, Buffalo Hydraulics Div, 537 E Delavan Ave, Buffalo 11, NY.

(J-164) 3000 Psi Self-sealing Couplings—Bulletin, 8 pp. Shows construction, operation and applications; gives materials, weights, qualification tests and installation procedures. Aeroquip Corp, 300 S East Ave, Jackson, Mich.

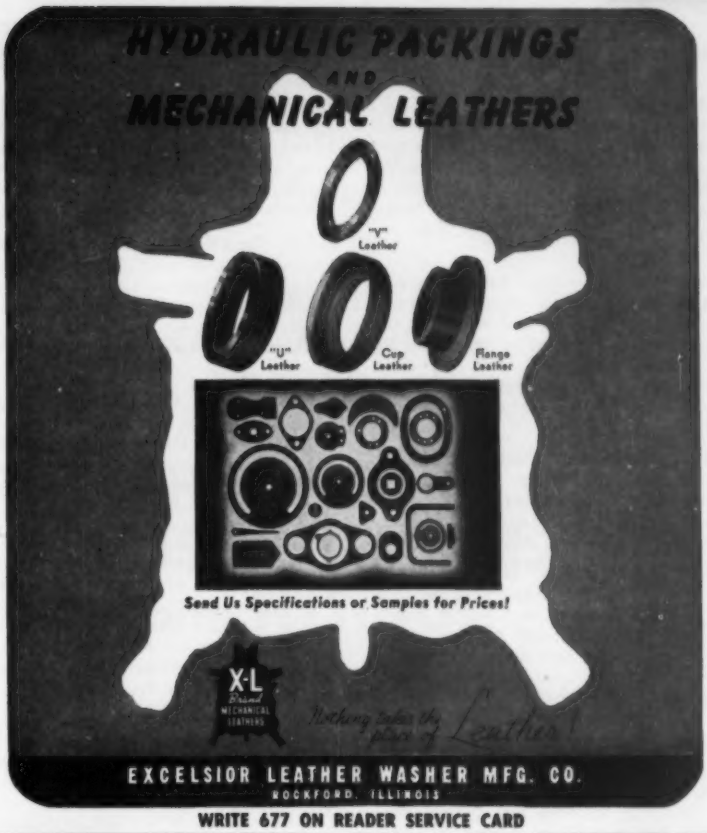
(J-165) Flow Dividers, Selector and Relief Valves—Brochure, 8 pp. Provides operational drawings, dimension diagrams, installation data and applications for various sizes. New Products Corp, 3636 Oakton St, Skokie, Ill.

(J-166) Hydraulic Cylinders—Catalog, 42 pp. Describes various bore sizes, strokes and types for all OEM and industrial applications. Cross Mfg Co, Lewis, Kansas.

(J-167) Pumping Units—Catalog, 8 pp. Contains selection chart, prices, ratings and describes construction features of centrifugal and gear types. Graymills Corp, 3705 N Lincoln Ave, Chicago 13, Ill.

(J-168) Air Control Products—Catalog, 85 pp. Describes air cylinders and presses, 2-, 3- and 4-way air valves, blow guns, couplers, flow control valves, air hose and ejection sets. A Schrader's Son, Div of Scovill Mfg, Inc, 470 Vanderbilt Ave, Brooklyn 38, NY.

(J-169) Oil and Grease Seals—Catalog, 96 pp. Lists types and sizes available together with technical engineering information and design usage suggestions. National Seal Div, Federal-Mogul-Bower Bearings, Inc, Broadway at National, Redwood City, Calif.



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(J-170) **Automatic Valve Operators**—Brochure, 4 pp. Description of motorized valve operators for gate, plug, butterfly, globe and other valve applications, together with torque and seating thrust ranges. Electrodyne Operators, Hupp Aviation Co, 6633 W 65th St, Chicago, Ill.

(J-171) **Air Line Filters, Lubricators and Regulators**—Catalog, 16 pp. Illustrates and describes various units and assemblies for conditioning and control of compressed air to protect air powered tools and other pneumatic devices and appliances. Arrow Tools Inc, 1900 S Kostner Ave, Chicago 23, Ill.

(J-172) **Hydraulic and Pneumatic Molded Packings**—Catalog, 37 pp. Describes construction and applications. Gives mold sizes and critical dimensions. Periflex, Inc, 111 Ten Mile Rd, Hazel Park, Mich.

(J-173) **Rotating Pipe Unions**—Catalog, 20 pp. Describes rotating pipe unions for the transmission of air, water, steam, chemicals, coolants and vacuum from stationary supply line to rotating cylinders, rolls, clutchs and machine parts. Deublin Co, 1919 Stanley St, Northbrook, Ill.

(J-174) **Airless and Hydraulic Spray Coating Equipment**—Catalog, 4 pp. Describes spray painting equipment for atomizing or delivering finishing and coating materials. Nordson Corp, Jackson St, Amherst, Ohio.

(J-175) **Push-pull Hydraulic Coupling**—Bulletin, 4 pp. Illustrates various types and sizes; gives specifications and ordering information. Aeroquip Corp, 300 S East Ave, Jackson, Mich.

(J-176) **Hydraulic Buffer**—Brochure, 16 pp. Technical description includes cross-section and application theory together with drawings of typical units for limiting travel of large radar antennae. Houdaille Industries, Inc, Buffalo Hydraulics Div, 537 E Delavan Ave, Buffalo 11, NY.

(J-177) **Oilless Air Compressors**—Catalog, 12 pp. Oil free air is delivered by line of air compressors and vacuum pumps. Available in portable, tank-mounted and tankless models. Bell & Gossett Co, 8200 N Austin Ave, Morton Grove, Ill.

(J-178) **Hose Fittings**—Catalog, 8 pp. Gives recommended uses, sizes, operations and component parts for various couplings, clamps, valves, nipples, and others. Hose Accessories Co, 2732 N 17th St, Philadelphia 32, Pa.

(J-179) **Valves**—Catalog, 76 pp. Gives engineering data on line of valves, sizes ¼ in., to 2 in. for hydraulic and other fluid services. Republic Mfg Co, 15655 Brookpark Rd, Cleveland 35, Ohio.

(J-180) **Hydraulic Cylinders**—Bulletin, 4 pp. Describes construction and provides installation information on the several type mountings available for 200, 1000, 1800 psi pressures. Bendix-Westinghouse AAB Co, 901 Cleveland St, Elyria, Ohio.

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(J-182) **Flexible Hose and Tubing**—Catalog, 10 pp. Gives specifications, diameters, materials and construction information on flexible metal hose assemblies designed to convey gases, solids and fluids. Universal Metal Hose Co, 2133 S Kedzie Ave, Chicago 23, Ill.

(J-183) **Hydraulic Valves**—Catalog, 12 pp. Describes manually operated 4-way valves of lever, cam and foot operated type; 2000 and 3000 psi pipe, sub-plate mounted. Also, includes dimension drawings, piston designs and flow operations. Rivett Lathe & Grinder, Inc, Brighton 35, Mass.

(J-184) **Air Cleaners**—Brochure, 4 pp. Various types of air cleaners for internal combustion engines, both gasoline and diesel. Gives maintenance instructions, features and dimensions of filters. Donaldson Co, Inc, 666 Pelham Blvd, St. Paul 14, Minn.

(J-185) **Piston Pumps**—Bulletin, 8 pp. Contains specifications, description of parts and operation, representative performance curves, installation and ordering information for 6 and 10 piston axial types designed for mobile and industrial applications up to 6000 psi. Dynex Inc, 777 Dynex Drive, Pewaukee, Wis.

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(J-190) **Pipe Couplings**—Catalog, 40 pp. Contains product information and specifications, installation instructions, engineering recommendations and tables, possible applications, and ordering information. Dresser Industries, Bradford, Pa.

(J-191) **Small Valves**—Catalog, 8 pp. Describes line of forged needle, panel mounted, bar stock, metering and toggle valves; micron filters and technical engineering information. Hoke, Inc, 1 Tenakill Park, Cresskill, NJ.

(J-192) **Industrial Hose and Fittings**—Catalog, 68 pp. Describes construction and applications; gives engineering information, test results, typical diameters and ordering information. Aeroquip Corp, 300 S East Ave, Jackson, Mich.

(J-193) **Valves and Fittings**—Bulletin, 6 pp. Describes construction and applications; gives sizes, weights and ordering information. Strataflo Products, Inc, 4939 S Lafayette St, Ft Wayne, Ind.

(J-194) **Air Compressors**—Catalog, 11 pp. Describes line of air compressors, from ½ hp through 20 hp, air and water cooled, single and two stage. Quincy Compressor Co, 217 Main St, Quincy, Ill.

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(J-200) **Industrial Air Controls**—Catalog, 31 pp. Describes construction, applications and mounting dimensions of diaphragm type chambers; list various types of air control valves, gages and chambers. Bendix-Westinghouse AAB Co, 901 Cleveland St, Elyria, Ohio.

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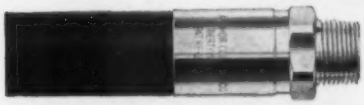
(J-202) **Hydraulic Power Checks**—Catalog, 4 pp. Gives technical and application data regarding hydraulic power checking of motion. Appco Corp, 25561 Mill St, Olmsted Falls, Ohio.



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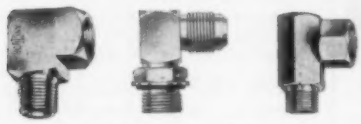

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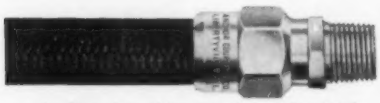

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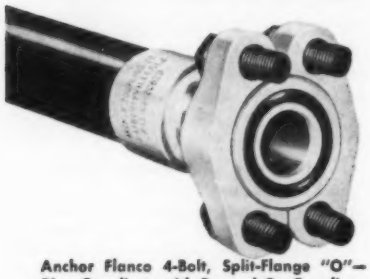

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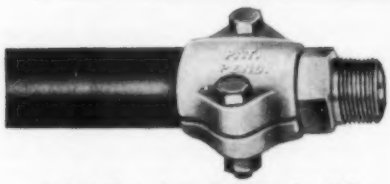

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(J-205) Valve and Cylinder Combinations—Bulletin, 12 pp. Presents data on materials, life expectancy, maintenance, mounting, coil rating and dimensions. Includes drawings, flow chart and selection formulas for 1, 1¼, and 1½ in. bores with 0-200 psi range. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9, Ohio.

(J-206) Hydraulic Rotary Actuator—Brochure, 4 pp. Describes design, construction materials and special features. Uses include servo rotary mechanism and power hinge installations. Aeroproducts Operations, Allison Div, GMC, Municipal Airport, Dayton 1, Ohio.

(J-207) Oilers, Tube Forms and Check Valves—Catalog, 12 pp. Describes tube fabrication facilities, machine thread sizes, specifications, drawings and photographs of typical oilers and others. Eynon-Dakin Co, 9900 Freeland Ave, Detroit 27, Mich.

(J-208) Rotary Air Products—Brochure, 12 pp. Shows original equipment applications of air motors, compressors and vacuum pumps, plus drawings illustrating principles of each application. Gast Mfg Corp, PO Box 117 Benton Harbor, Mich.

(J-209) Fluid Flow Fittings—Catalog, 23 pp. Shows o-ring seal tube fittings, 2- and 3- piece 37 degree flare fittings, tube benders, steel tubing and related hydraulic items. Also contains flow charts and JIC piping procedures. Lenz Co, 3301 Klepinger Rd, Box 1044, Dayton 1, Ohio.

(J-210) Rams and Pumps—Catalog, 27 pp. Dimensions and performance curves for hydarulic pumps, valves and cylinders. Donnell Hydraulic Co, Marengo, Ill.

(J-211) Electrically-operated 3-way Valves—Bulletin, 6 pp. Contains general specifications, operating principles, flow patterns, optional features, service parts and ordering information. Airmatic Valve, Inc, 7313 Associate Ave, Cleveland 9, Ohio.

(J-212) Hydraulic Pumps—Bulletin, 2 pp. Contains listing of prices and mounting information for single, double and combination pumps using standard hydraulic oils or fire-resistant fluids. Double A Products Co, Div Brown & Sharpe Mfg Co, Manchester, Mich.

(J-213) Hydraulic Pumps and Fluid Motors—Bulletin, 12 pp. Describes line of hydraulic pumps delivering up to 9.8 gpm and 1500 psi, and fluid motors capable of producing up to 5 hp. Eastern Industries, Inc, 100 Skiff St, Hamden 14, Conn.

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(J-224) Flange Fittings—Catalog, 27 pp. Pipe sizes, hole diameters, threads, dimensions and diagrams of weld-type hydraulic fittings. Anchor Coupling Co, Inc, 342 N 4th St, Libertyville, Ill.

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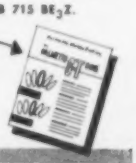

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(J-229) Mechanical Packings—Catalog, 17 pp. Gives construction details, specifications and standards for line of back-up rings, spiral packings, synthetic vee and U cups. Searle Leather & Packing Co, 2105 N Mariana Ave, Los Angeles 32, Calif.

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(J-232) Air and Hydraulic Cylinders—Bulletin, 8 pp. Describes design and construction of standardized cylinder which can be used for either pneumatic or hydraulic application. Lindberg Air & Hydraulic Div of Teer-Wickwire & Co, 1801 Wildwood Ave, Jackson, Mich.

(J-233) Valves and Latch Pins—Catalog, 16 pp. Fires by means of self-contained explosive squib. Provides operational drawings, specifications, prices, temperature curve and sales information. Conax Corp, 2300 Walden Axe, Buffalo 25, NY.

(J-234) Hydraulic Control Manifolds—Brochure, 4 pp. Describes construction features, vibration resistance, sealed-in flow lines and maintenance savings of hydraulic control manifolds. Takeoff charts, application and ordering instructions. Almo Manifold & Tool Co, PO Box 161, 11470 Kaltz, Centerline, Mich.